The Death of Neo-Darwinism

Dawkins vs Noble

Subboor Ahmad
Salman Butt

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Reflect deeply upon the creation, but do not reflect upon the essence of the Creator. Truly, His essence cannot be known other than to believe in it.

— Prophet Muhammad (peace be upon him)

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Preface

Atheism, as a belief system, has faced significant challenges in establishing itself as a foundational component of civilization in both Eastern and Western contexts. Historically, atheistic beliefs emerged in isolated pockets but gradually diminished over time. In the 20th century, however, atheism gained prominence in predominantly communist nations, where it was often institutionalized as the state ideology. Countries such as Czechoslovakia, Hungary, Bulgaria, the Congo, Russia, and Yugoslavia adopted atheism as their official stance, leading to the repression of religious practices through state violence and propaganda. Karl Marx famously asserted, "Communism begins where atheism begins,"[1] highlighting a systematic effort to eradicate religion, which included closing places of worship and persecuting religious leaders. Although this wave of state-sponsored atheism has since declined, it continues to persist in countries like China and North Korea.

Despite experiencing considerable setbacks at the state level during the 20th century, atheism saw a resurgence at the grassroots level in the early 21st century, largely driven by Richard Dawkins' influential work, *The God Delusion*. Similar to Marx's *The Communist Manifesto*, Dawkins aimed to eradicate religion and quickly garnered a substantial following. This movement, often referred to as New Atheism, sought to fill the void left by the decline of Christendom in Europe. For many, the perceived incompatibility of science and faith prompted a search for answers within nihilistic, materialistic, and reductionist worldviews. In his earlier work, *The Selfish Gene*, Dawkins introduced a perspective that centers on the self, viewing DNA as the ultimate authority. This individualistic outlook resonated with those disillusioned by traditional religious frameworks.

Dawkins' advocacy for atheism is heavily grounded in Neo-Darwinism; however, it frequently lacks logical coherence. Neo-Darwinism need not be incompatible with theism, allowing for the possibility of maintaining theistic beliefs while embracing evolutionary principles. Nevertheless, Dawkins' intense disdain for religion often leads him to overreach, arguing that Dar-

winism undermines the existence of God and venturing into philosophical domains where his expertise is less pronounced. Importantly, Dawkins fails to recognize that his interpretation of atheism, rooted in Neo-Darwinism, contradicts Charles Darwin's own beliefs. Darwin maintained a belief in a higher power for much of his life and suggested that one could be both an evolutionist and a theist.

Dawkins' approach is characterized by a reluctance to engage with academic critics. His tendency to address an already convinced audience limits meaningful discourse, as evidenced by his inadequate responses to prominent critics such as Michael Ruse, Alister McGrath, Keith Ward, Stephen Myer, William Dembski and William Lane Craig, who have effectively countered his arguments. When confronted by academic theists like Hamza Tzortzis, Dawkins often displays evasiveness and condescension. In one notable exchange, Tzortzis highlighted the shortcomings in Dawkins' critique of the design argument, pointing out the flawed notion that evolution negates design in the universe[2]. Dawkins failed to provide a satisfactory response, opting instead for a dismissive approach that reflects both a lack of philosophical understanding and an unwillingness to engage academically with believers.

In stark contrast, Denis Noble exemplifies a more open and collaborative approach. Noble engaged in a comprehensive dialogue with the theist academic Qaiser Ahmad Raja, covering topics such as purpose, design, agency, and theology[3]. Despite their differing perspectives, Noble respected Raja's theological viewpoints, acknowledging that their discussions transcended biology and ventured into philosophical territory. He recognized that while he may not share theists' interpretations, he respects their perspectives. Their conversation presented a refreshing alternative to the often dogmatic and polemical discourse characteristic of New Atheism.

Theists resist Dawkins' extreme gene-centrism, which seeks to eliminate metaphysics, morality, and meaning from consideration. This reductionist perspective stems from Dawkins' misunderstanding of Neo-Darwinism and its broader implications. Noble, though not a believer himself, adopts a more congenial stance toward theists, recognizing that philosophical issues extend beyond scientific inquiry and that such questions cannot be categorically resolved as Dawkins proposes.

In light of these discussions, we have undertaken the writing of this book to critically examine Neo-Darwinism, which underpins Dawkins' worldview. Our focus will center on the work of Noble and his public debate with Dawkins, during which Noble effectively illuminated the fundamental flaws in Dawkins' arguments. Noble advocates for a systems-based understanding of biological entities that rejects the reductionism inherent in Dawkins'

gene-centered view, dismantling the foundations of Neo-Darwinism while proposing a new paradigm for future exploration.

It is essential to clarify that this work is not a theological treatise but rather a scholarly exploration of science and philosophy, addressing the critical questions raised by two influential scientists of our time. It extends beyond their individual debates to examine the broader scientific landscape, incorporating diverse perspectives and arguments. Our aim is to illustrate the futility of constructing a belief system solely based on a scientific theory that is inherently subject to revision.

By echoing the sentiments of Thomas Kuhn, who cautioned against an overattachment to scientific theories amid paradigm shifts, and Max Planck, who noted that scientific progress often arises from the demise of old ideas[4], we aspire to contribute to a generational shift in understanding. Ultimately, this book seeks to foster a deeper appreciation for the complexities that lie at the intersection of scientific inquiry and philosophical discourse.

CHAPTER 1

Introduction

> "Neo-Darwinism: a theory of evolution that is a synthesis of Darwin's theory in terms of natural selection and modern population genetics"[5]

Oxford biologist Denis Noble boldly declared that "Neo-Darwinism is dead."[6] He claims that "all the central assumptions of the Modern Synthesis (often also called Neo-Darwinism) have been disproved. Moreover, they have been disproved in ways that raise the tantalising prospect of a totally new synthesis…"[7]

These claims are surprising for large swathes of the scientific community to whom Neo-Darwinism remains as indispensable a theory today as it was when it was first formulated. Neo-Darwinism—defined loosely as Darwinism coupled with Mendelian genetics—forms the cornerstone of modern evolutionary theory.[8] This centrality of Neo-Darwinism has led to it being the subject of countless peer-reviewed articles, classroom exercises, and seminars in lecture halls over the past century. Noble's claims, therefore, are not without consequence, nor should they be accepted without thorough scrutiny.

To some, including Neo-Darwinism's fiercest and most popular proponents, such as Richard Dawkins, the theory transcends into what effectively amounts to religious dogma. Dawkins, in particular, has been defending the theory for decades, whilst using its principles axiomatically to further psychosocial narratives he holds to be true. His fervour and charisma, coupled with a knack for distilling complex topics into digestible soundbites, have helped propel him to a rare tier of fame within the scientific community. Dawkins' book *The Selfish Gene* is his most famous literary

output and it was received warmly by the scientific community, being voted as the most inspiring science book of all time in a poll conducted by The Royal Society.[9] Geneticist Adam Ruderford wrote in The Guardian, "The Selfish Gene has attained its own literary and scientific immortality: as long as we study life, it will be read."[10]

Dawkins' writings have had a major influence on the public understanding of the theory of evolution. His coupling of Neo-Darwinism with an anti-theistic worldview has brought together swathes of the laity who were hitherto uninterested in one or the other of these paradigms. Dawkins' polemics in favour of Neo-Darwinism have bolstered the confidence many have in the theory.

It is unsurprising, then, that Noble's criticism of Neo-Darwinism have both attacked the theory and its most famous proponent. Previously, Dawkins and Noble had long known each other as professors at Oxford University. Despite their academic disagreements, their personal relationship had been amicable. In 1966, when Dawkins was studying for his PhD, Noble had been his doctoral examiner. Back then, Dawkins had fully embraced Neo-Darwinism whilst Noble had his doubts. After the publication of *The Selfish Gene* in 1976, Noble praised Dawkins' ability to articulate Neo-Darwinism in a lucid manner, which had popularised the topic in unprecedented ways.

Noble refrained from publicly criticising Dawkins' work until he published *The Music of Life* in 2008. In this text lay an open challenge to Neo-Darwinism and its proponents. In 2014, Noble and other biologists launched an initiative called The Third Way of Evolution, which they offer as a different perspective to the standard Neo-Darwinian theory. They summarise their alternative approach as follows:

> "The vast majority of people believe that there are only two alternative ways to explain the origins of biological diversity. One way is Creationism that depends upon intervention by a divine Creator. That is clearly unscientific because it brings an arbitrary supernatural force into the evolution process. The commonly accepted alternative is Neo-Darwinism, which is clearly naturalistic science but ignores much contemporary molecular evidence and invokes a set of unsupported assumptions about the accidental nature of hereditary variation. Neo-Darwinism ignores important rapid evolutionary processes such as symbiogenesis, horizontal DNA transfer, action of mobile DNA and epigenetic modifications. Moreover, some Neo-Darwinists have elevated Natural Selection into a unique creative force that solves all the difficult evolutionary

> problems without a real empirical basis. Many scientists today see the need for a deeper and more complete exploration of all aspects of the evolutionary process."[11]

Noble's criticism of Dawkins led to a well-known debate in 2022 in which the two met to defend their ideas. During this debate, Dawkins summed up Neo-Darwinism with the following statement:

> "The Neo-Darwinian theory which Denis has a lot of criticism of in his book is a theory of differential survival of genes in gene pools and that only matters if the genes are potentially able to survive in the gene pool for a very long time. The ones that do survive are the ones that have a beneficial causal influence on every body on which they find themselves. Successive generations, the genes find themselves in bodies again and again. The ones that survive over many generations will be the ones that have a causal influence on a long succession of bodies."[12]

Dawkins' central belief is that genes are the primary driving forces that shape our physical bodies and minds. He accepts that if Noble is to be proven correct, it would mean that he and all those like him were, in fact, mistaken for many decades. Further, he accepts that Neo-Darwinism is not a fact on the level of a absolute truth, in an earlier work he explains this point:

> "We can now assert with confidence that the theory that the Earth moves round the Sun not only is right for our time but will be right in all future times even if flat-Earthism happens to become revived and universally accepted in some new dark age of human history. We cannot quite say that Darwinism is in the same unassailable class. Respectable opposition to it can still be mounted, and it can be argued that the current high standing of Darwinism in educated minds may not last through all future generations. Darwin may be triumphant at the end of the twentieth century, but we must acknowledge the possibility that new facts may come to light which will force our successors of the twenty-first century to abandon Darwinism or modify it beyond recognition."[13]

This book sets out to scrutinise this ongoing debate and its implications of the standard model of Neo-Darwinism being taught today.

CHAPTER 2

A Brief History of Neo-Darwinism

The popularisation of a technical field be that a field of science, literature, or religion invariably leads to a degree of ambiguity about the field in public discourse. Following this, it becomes all too easy to strawman a worldview for polemical purposes. Thus, it is essential that one fairly reconstructs a paradigm before attempting to deconstruct it. An understanding of the history of Neo-Darwinism should help clarify a number of its core tenets and major proponents, as well as their arguments in favour of the theory. For many of its well-known advocates, Neo-Darwinism being uprooted as the dominant paradigm of evolutionary biologists would lead to intellectual embarrassment, theological conundrums, and perhaps even a loss in sense of self-worth. Conversely, for opponents of the theory, they are set to gain newfound fame and the chance to impose their worldviews onto academies worldwide. These biases are important to consider when discussing any topic, and we mustn't feign objectivity to maintain façades of impartiality. Alasdair Macintyre once wrote, "The neutrality of the academic is itself a fiction of the encyclopaedist, and I reveal my antiencyclopaedic partisanship by calling it a fiction."[14]

At the outset, one must appreciate that evolution as a broader concept, and the multiple theories of evolution as specific interpretations of this concept, are distinct entities. Evolution as a concept appears to have first been conceived of millennia ago, with rudimentary ideas put forward by Greek and Indian civilisations. Many Greek philosophers worked with the idea of iterative changes in the natural world that led to increasingly well-developed species. Aristotle, himself, proposed the idea of their being a "great chain of being" [*scala naturae*] with humans at the top of this hierarchy as the most advanced and perfect form of being.[15] Anaximander,

another Greek philosopher, hypothesised that all living beings, including humans, descended from a common aquatic ancestor.[16]

In ancient Indian scriptures, such as the Vedas and the Upanishads, humans are viewed as being a part of a cyclical and interconnected web of being. Manu, the legendary first man and lawgiver according to Hinduism, is credited by Hindus to have written a treatise now referred to as the Manu-smriti, in which he argued that life forms could evolve and adapt to environmental stresses, transforming from their original states.[17] Manu even claimed that humanity had arisen from an earlier, more primitive creature.[17] In the words of Monier Monier-Williams, Hindus were "Darwinians many centuries before Darwin; and Evolutionists many centuries before the doctrine of Evolution had been accepted by the Scientists of our time."[18]

These Indo-Greco viewpoints were not uniform, nor were they based on large swathes of empirical data, but they were existent and prominent in their own circles. The proponents of such views grappled with fundamental questions surrounding iterative change, progressive development, and species-wide transformation. Hierarchies and order characterised the Greek world whilst cyclical continuities and equilibria characterised the Indian one. Together, they laid the conceptual groundwork for the modern scientific understanding of evolution.

Modern evolutionary theories began to develop in the 18th century. French naturalist Jean-Baptiste Lamarck proposed a theory which held that organisms could pass on traits they developed throughout their lives—a concept now known as the inheritance of acquired traits.[19] This landmark theory was the first naturalist theory of evolution to have entered public discourse. Lamarck hypothesised that organisms could acquire and dispose of traits based on environmental pressures through a law of use and disuse.

In the 19th century, Charles Darwin and Alfred Wallace independently began to develop theories of natural selection, representing a major paradigm shift from the work of Lamarck. Unlike Lamarck, both Darwin and Wallace claimed that organisms within a species varied in significant ways, and that random changes led to the development of novel traits, which itself led to the persistence of certain traits and the loss of others. Over time, this adaptation would lead to the development of organisms almost unrecognisable from their original species.

A key difference between the theories of Lamarck and those of Darwin and Wallace is their understanding of the locus of variation. To Lamarck, the environment was the primary stressor that led to evolutionary change. To Darwin and Wallace, a struggle for survival lay behind the propagation of certain organisms at the expense of others. A further difference is that Lamarck saw organisms as being capable of active adaptation to environ-

mental pressures, which could then be passed on, whereas Darwin and Wallace saw change as a random process that was independent of the needs of an organism.

In his later years, Darwin appears to have acknowledged the validity of some of Lamarck's ideas, though Wallace did not share these sentiments and Neo-Darwinists today often downplay them.[20] It is perhaps for polemical, though counterintuitive, reasons that this is the case in the modern world. For fear of losing ground on their cherished paradigms and figures, Neo-Darwinists of today tend to veil the more open-minded aspects of Darwin's nature.

Despite their differences, all three thinkers made significant contributions to our understanding of evolution. Lamarck's theory of evolution has now largely been discredited, though his writings on the role of the environment in driving adaptation have had a lasting impact. Darwin and Wallace's theories have been refined and adjusted, and they remain foundational to modern discussions in evolutionary biology. Darwin, being the more well-known of the two, has seen his work have an impact on many branches of science, from psychology to sociology to philosophy.

Modern evolutionary theory has progressed significantly since Darwin's landmark text, *On the Origin of Species*. In 1883, just a year after Darwin had died, a German biologist named August Weismann developed a theory of germ plasm, in which germline cells were distinct from the soma. Weismann proposed a barrier between the two that prevented information exchange from the germ plasm to the soma, and vice versa. Prior to this distinction, Darwin's theory of evolution had focussed on inherited phenotypes that provided evolutionary advantages to their possessors. Following Weismann, the narrative shifted. No longer were phenotypic variations the primary driver of natural selection; genotypic variations took this central position. This new theory was called Neo-Darwinism, and it emerged as the intellectual successor to classical Darwinism.

Around this same time, an Austrian biologist and mathematician named Gregor Mendel was developing a system of inheritance that identified traits with loci on chromosomes. He sought to explain the probabilistic nature of inheritance and the nature of this information exchange process. Then in the 20th century, the Modern Synthesis of evolutionary theory began to emerge, in which Neo-Darwinism and Mendelian genetics were co-applied to the concept of natural selection. To quote Noble:

> "Mendel's genetic experiments were unknown when the term Neo-Darwinism was coined at the end of the nineteenth century. One of the reasons why Neo-Darwinism developed into what

> is called the Modern Synthesis is the integration of Mendelian genetics into the Neo-Darwinist framework."[21]

That being said, it is common practice among biologists to use the terms Neo-Darwinism and the Modern Synthesis interchangeably, and this is done by both Dawkins and Noble themselves.

The Modern Synthesis brought together a number of scientific fields of enquiry, such as palaeontology, genetics, and sociology, to form a comprehensive understanding of evolution that persists to this day. It provides a framework through which one may make sense of variations within species, the inheritance of certain traits, the relative persistence of certain traits over others, and the adaptation of populations over time. Thus, it provides biologists with a robust paradigm through which they may view the organic world.

Key contributors to the Modern Synthesis include Ronald Fisher, Theodosius Dobzhansky, Ernst Mayr, and Julian Huxley. Richard Dawkins and George Williams have taken these ideas and pushed further to expand the modern understanding of evolutionary biology. Their gene centric argument avers that natural selection primarily functions at the genetic level and not the organism or species levels. Noble writes, "The selfish gene idea is a popularization of Neo-Darwinism which goes beyond it to characterise genes as elements in organisms with specific (selfish) behaviour."[22]

Dawkins argues that genes are fundamental units of inheritance, and that they are the primary drivers of evolution, with genes involuntarily acting in a selfish manner to maximise their own replication and propagation. It is to say that genes, and not bodies, are the primary driving force behind the development and evolution of living organisms. This idea quickly gained traction in the late 20th century and has been formative for much of the subsequent discourse on evolution.

Now, in the 21st century, it is precisely this relied-upon framework that Noble is challenging. To challenge minutiae is unnerving, to challenge an entire episteme is destabilising.

Denis Noble argues that Neo-Darwinism rests upon four foundational pillars. In brackets next to each pillar, I have given the pillar a name for easy reference herefrom. These pillars are:

i. the hypothesis that alterations in the structure and function of organisms within a single generation cannot be transmitted through the germ line (henceforth, Weismann barrier pillar);

ii. the hypothesis that organisms are incapable of changing their own genetic makeup, making causation unilateral and not allowing for

the possibility of the environment to affect genes (henceforth, central dogma);

iii. the hypothesis that an organism is a passive vessel for preserving genes within a pool, and that the behaviour and function of the organism work toward this purpose (henceforth, passive filter pillar);

iv. the hypothesis that evolution occurs through minor random alterations in genes that are passively favoured through a process of natural selection (random error pillar).[23]

In response to these, Noble claims that:

i. selective changes in organisms can, in fact, be passed on through the germ line, suggesting that there are no firm barriers;

ii. causality is bilateral and organisms can change their own genetic makeup based on environmental stressors;

iii. the active involvement of organisms in their own evolution means that any notion of a distinct, selfish gene pool existing separately from a body—and not being dependent upon it—is indefensible;

iv. the ability of organisms to change their own genetic makeup means that genomes have undergone major reorganisations throughout time.[23]

Though subtle, the implications of Noble's contentions on our understanding of evolution are enormous. They seek to dismiss the long-held beliefs about selfish genes and passive organisms. Instead, they restore agency to organisms and place genes as a factor, among many factors, that determine the precise nature of a species. Mind and body are no longer subservient to a genetic code they are powerless to alter. Noble's holistic view of evolution does away with much of the reductionism that characterised 20th century evolutionary biology. Ontologically, he shifts the paradigm away from the pixels of yesteryear and onto the picture of today.

This book will explain Denis Noble's arguments and Richard Dawkins' responses. It will show how Noble effectively dismantled Neo-Darwinism and how, bafflingly, the debate persists even though Neo-Darwinism has long been declared deceased.

CHAPTER 3

Noble's Doubts

In 1953, Watson and Crick identified the structure of deoxyribonucleic acid (DNA). It won them each a Nobel prize and changed the course of biology forever.[24] A few years later in 1957, Crick lectured a congregation of biologists at University College London on the central dogma of molecular biology, arguing that the flow of genetic information is unilateral, from DNA to RNA to proteins.[25] In other words, genotypes affect phenotypes, but not the other way around. Since then, and until recent advancements in molecular biology, this belief was considered axiomatic and indispensable.

These theories quickly popularised and led to a gene-centric understanding of the organic world. They painted a picture of a world in which genes function as instruction manuals to build organisms. The picture dichotomised genomes and bodies, with the former being considered an active and causal actor and the latter a passive and caused recipient. In *The Selfish Gene*, Dawkins wrote favourably of this central dogma:

> "They did not die out, for they are past masters of the survival arts. But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines."[26]

This gene-centrism affords genes power and agency that it does not afford bodies and minds. Bodies and minds, what we intuitively understand as being 'us', are seen as repositories for our gene overlords. Genes are thought to contain all the necessary information required to determine life, and they are the focus of the evolutionary process. Noble discusses some of the implications of this understanding:

> "By unravelling the 'code' we could find the ultimate or 'primary' cause of life and its functions. It led to the new field of genomics, which would seek to associate particular genes, or groups of genes, with particular functions. But if all functions could be reduced to genes, then this produces a problem: where lies the agency of organisms? Could this also be reduced to genes? Are we driven by genes? The answer presented by those central to what came to be called the Modern Synthesis was that it could — even to the point of arguing that our freedom to act (free will) and our agency is an illusion."[23]

It is this point that Noble has been fighting so intensely over the past two decades, and this was the first point of contention between Noble and Dawkins during their debate. Dawkins said:

> "To me, the argument today is about one paragraph in Denis' excellent book 'Dance to the Tune of Life', which is a wonderful book, except that it is wrong. The paragraph concerned is 'This book will show that there are no genes for anything, living organisms have functions which use genes to make the molecules they need—genes are used, they are not active causes.' Now, I think that is a wonderful sentence, because, although it is wrong, it is clear—it is absolutely clear and open and articulate, and that makes my job relatively easy, because I want to show the exact opposite is true. The truth is opposite: genes use individuals, use organisms as tools for their own propagation."[12]

Noble's holistic framing of the matter meant he afforded individual organisms more agency than his interlocutor did. If genes are not independent directors of events, then they are part of a wider network of connections that make up a person. To many, the point may seem trivial, but for Dawkins, this disruption of his gene-centrism allows for more vitalistic worldviews, and with them arises an inevitable metaphysics he wishes to suppress. It is not just a definitional dispute, there are logical entailments that both

interlocutors are considering, and it is primarily these endpoints they wish to defend or dispute.

This needn't be the case, however, as metaphysics is entirely possible given either paradigm, but for Dawkins, it is an ideological point in need of defending. Dawkins felt the need to defend a wholly reductionist viewpoint, in which the idea of personal agency was a complete illusion, conjured up by genetic puppeteers. There is an extreme level of determinism that results from this belief, which makes Dawkins' passion and persistence all the more jarring. It is difficult to ignore the obvious paradox on show, as such passion and enthusiasm belies the very determinism and fatalism that he purports to believe.

As for Noble, he believes that genes are involved in a much wider apparatus of life, writing, "they are part of a regulatory system and not its directors."[23] Genes alone do not make life single handedly, nor are they independently preserved. They arose from something and rely on other things to function. Further, they are unable to direct the organisms that are built through them.

During the debate, Dawkins posed a hypothetical scenario:

> "Suppose you put Denis' genome in a petri dish and keep it going for ten thousand years. Well, it wouldn't keep going; it would decay, as you rightly say. However, the information could be preserved on paper. You could actually write it down in a book, or you could carve the A, T, C, and G codons in granite and keep it for ten thousand years. Then, in ten thousand years, type it into a sequencing machine, which we already have, and it would recreate an identical twin of Denis Noble."[12]

Noble responded saying he does not think this method would reproduce his twin. Dawkins asked why and Noble responded, "Well, it would need one… It would need an egg cell."[12] Though subtle, this exchange holds the key to their primary difference. To Dawkins, genes are everything, they are the books of life. To Noble, genes are cogs in a wider machine, they are pages within the book of life.

Let us spend a moment dissecting both claims. Noble's mention of the egg cell represents a wider claim that it takes more to create a person than just his genes. This is not to just say that nature and nurture both do not affect our persons—which nobody disputes—but to say that nature itself is not completely dependent on the genome. Noble focused on the example

of the egg, but the egg is, again, not the only thing that affects our beings. In *The Genetic Book of the Dead: A Darwinian Reverie*, Dawkins writes:

> "Of course, the DNA information would need the biochemical infrastructure of an egg cell in a womb, but that could be provided by any willing woman. The baby she bears, an identical twin of its 10,000-year dead predecessor, would be living repudiation of Singer and Noble."[27]

Noble disagrees. Insufficient, in his view, is a genetic code—printed by a machine—and the egg of any willing woman to make an identical twin. He avers that the impact of the egg, external pressures during foetal development, and many other factors make a significant impact on the human that results. And since that is true, so too is the fact that a genome is not independent in producing life. One's physiology is more than just the product of A, T, C, and G nucleotides.

A parsing of the literature is striking. Philip Ball, in his book *How Life Works*, joins a great many scientists that have aim to show how a genome alone is insufficient to build an organism.[28] Noble published a review—aptly titled, *It's time to admit that genes are not the blueprint of life*—of this book in the journal *Nature*, wherein he lucidly explains that Dawkins' long-held view of life is outdated.[29]

Noble argues that agency is held by organisms, as all the conditional logic that an organism processes—those regulatory processes and mental flowcharts we circumnavigate constantly—are to be found outside of one's genome. He writes:

> "The organism does not wait for commands given by genes. Just as musical notes can be arranged in many ways to create compositions, organisms use their genetic heritage, implementing a diverse range of possible outcomes. Furthermore, when their heritage is inadequate to cope with environmental stress, organisms can alter their genes. Thus, organisms can change their genetic heritage."[23]

A large part of this discussion hinges on the matter of causality. Do genes cause everything or can other things affect genes? Dawkins and much of the scientific world for the past few decades have been toiling under the impression of the former. The latter is what Noble and others like him are now stressing.

The way each thinker tackled the issue of causality is interesting. To Dawkins, his opponents confuse correlation with causation. He uses the example of a rooster that crows whenever a clock strikes upon the hour.

One may erroneously assume that the clock striking the hour is what causes the rooster to crow—they'd be mistaken. Only if one is able to manipulate and study the situation can they truly identify causation. If they manipulated the clock, making it strike at random intervals, then observed the rooster's crows, only then could they definitively identify causation, or the lack thereof.[12]

It would be more accurate to say that, even then, one could not definitively deduce causation. If correlation does not equal causation, then even correlation post-manipulation and experimentation does not equal causation. Whilst incredibly unlikely, it may still be the case that the rooster randomly crowed whenever the clock struck the hour, even though you made those moments random. There may even be a variable confusing the matter that you had not considered. In no real-life scenario are there no other variables involved in an experiment. Perhaps the crow had crowed every time you looked at the clock, and you only looked at the clock as it struck the hour. You'd be excused for thinking this crow only crowed due to the clock—you'd be excused, but you'd still be wrong. What happens in reality is we approach higher degrees of certainty the more we experiment, but there is always room for error. Additionally, there is a greater philosophical mystery behind causality that deserves its own attention and conversation, but that is for another time. For the purposes of this thought experiment, Dawkins' hypothetical scenario is serviceable.

Causality, for Dawkins, is important as it dictates what—or whom—is the acting agent. If the genes are causal, unlike all else, then it is unfair to say that an organism has any command over them, at least according to this theory. Dawkins stresses that the genes which survive are those which continue to positively influence the organisms they inhabit. Selective pressure is applied and an ongoing process of evolution ensures that future gene pools are more adapted than earlier ones to any external stressors. An argument for natural selection—at least one which does not violate sacred principles, including those relating to the creation of man—is largely accepted and acceptable to most readers the world over. Where Dawkins ventures off, however, is in his framing of this. Dawkins claims, rather boldly, that this natural selection process means that our genes are the masters and that all else is its subjects.

Noble, upon hearing this argument during the debate, responded, "I love that introduction, Richard, because thirty years ago I did precisely that experiment! Let's go through it carefully, because I think the experiment is important."[12] The experiment being referred to took place in 1985, when Denis Noble and Dario DiFrancesco published a landmark paper in the Royal Society's *Philosophical Transactions*, titled, *A model of cardiac*

electrical activity incorporating ionic pumps and concentration changes.[30] According to the Royal Society itself, "This work had a profound impact on the field and its publication has been celebrated in the anniversary edition of Phil Trans B with an article written by David Eisner and colleagues."[31]

What, you may ask, is an article on cardiac electroconduction doing in a philosophy journal? Such a journal is, after all, an odd place for a discussion on physiology to be. The mystery unravels when you appreciate the purpose behind the article. Noble and DiFrancesco wished to show that genetic association cannot be used independently to predict causation in biological systems. The experiment looked at the case of genetic buffering—when one gene, 'responsible' for a certain function, stops functioning, then higher regulatory processes within the organism compensate to overcome this. This process is seemingly ubiquitous in nature.

Noble claimed that most genome sequencing and association studies demonstrate low levels of association between specific genes and specific traits. Phenotypes appear to be linked to only a few outlier genes that are crucial to the organism. However, these genes can be overridden, suppressed by other parts of an organism. That they can be shut off is proof that they are not masters in-and-off themselves. Something which continues to live long after its 'master' dies was never truly a puppet of this so-called master. Further, such symbiosis, interchangeability, and co-dependence really doesn't fit the picture of gene overlords controlling zombie bodies that Dawkins so poetically portrayed. Not only that, but the idea of a one-way avenue of causation does not check out either. How can it be the case when we have identified examples of organisms affecting genes?

In an international, collaborative study published in *Nature*, Lander et al. demonstrated that entire protein domains have been rearranged over time—a quite remarkable development in the field.[32] Under a Neo-Darwinian framework, this ought not to occur, as genes are supposed to drive an evolutionary process through small, random genetic mutations. If organisms themselves are causing genetic rearrangements, then it means that intentional, rapid evolutionary changes are possible. Random changes need not be the sole, or even the primary, cause of adaptation. Both the random error pillar and the passive filter pillar from the previous chapter are thus undermined.

In *The Blind Watchmaker*, Dawkins' 1986 anti-theistic book, he explained that a self-correcting system in which the correct components for iterative progression are maintained can rapidly achieve a desired outcome.[33] Noble agrees with the concept but avers that Dawkins was "right, but probably for the wrong reasons."[12] Instead, he proposes that the mechanism that iterates itself is the organism, and that genes are components of

this organism, which need to be adequately maintained for the organism to function well. If the genes malfunction, the organism works to correct this. If the malfunction is too severe, then the organism dies, just as a mechanical device would die if a crucial part of it malfunctioned beyond repair or replacement.

Recall the central dogma of Neo-Darwinism from the previous chapter: the hypothesis that organisms are incapable of changing their own genetic makeup, making causation unilateral and not allowing for the possibility of the environment to affect genes. Noble's experimentation and argumentation undermined this pillar directly. The empirical evidence for the undermining claims is rapidly growing in volume.[34] Dawkins describes selfish genes as a remote control in charge of a body. He does not seem to have taken a step back and understood that a human is operating that remote control. The fact that scientists have demonstrated how external influences on cells cause cell membrane proteins to change an organism's genetic code suffices to disprove Dawkins' claims. And whilst that is clearly so, we must not go to the other extreme in thinking that genes are altogether useless—they are crucial to every organism. The point here is to show that they are not the overlords of organisms; the truth is more complicated, and many conversations are taking place between structures.

CHAPTER 4

The Selfish Gene: a Metaphor or the Literal Truth

So, after all that, why does the idea of the selfish gene persist? What people often fail to mention is that there are clear ideological and polemical motivations underlying these falsely objective positions, and Dawkins' academic legacy demonstrates that these are major drivers of his discourse. However, to reduce the whole selfish gene argument down to individual biases and hopes is to overly trivialise it. There is more at play. For one, any notion of unilateral causation is difficult to dispel if the claims and conditions that make it so are not laid out clearly. 'Selfishness', in the selfish gene paradigm, is used metaphorically. There is no mind in Dawkins' deterministic, fatalistic worldview—only body. Therefore, no gene 'thinks'—thought is an illusion, as are your feelings, hopes, and human rights—all that exists are genes that have a survival advantage and thus propagate.

Dawkins wrote:

> "Natural selection will favour those genes which build themselves a body which is most likely to succeed in handing down safely to the next generation a large number of replicas of those genes… our basic expectation on the basis of the orthodox, Neo-Darwinian theory of evolution is that genes will be 'selfish.'"[35]

If Dawkins employs a notion of selfishness as a metaphor, it is still an incorrect one. However, as a metaphor, it allows for greater latitude in interpretation, as well as a degree of ambiguity that affords flexibility. For most biologists and lay readers, selfishness in this context is indeed a metaphor. Though, as pointed out by Noble, Dawkins vacillates between opinions on the literality of selfishness in his discourse.[7] Responding to a philosophical

critique by Mary Midgley against *The Selfish Gene*, Dawkins wrote, "… that was no metaphor. I believe it is the literal truth. Provided certain key words are defined in the particular way favoured by biologists."[36] This is a peculiar claim, as redefining a word in other than its typical meaning to show parallels is precisely what a metaphor is, and it precisely what Dawkins does.

Noble provides his own thought experiment to counteract this claim of literal selfishness. He invites one to consider two possible hypotheses: genes as prisoners and genes as selfish beings. He asks what experiment could be carried out to ascertain which of these hypotheses is most correct.[12] He uses this experiment to show how Dawkins' rather powerful but incredibly metaphorical language does not arrive at empirically sound conclusions.

Let us consider the following two statements by Dawkins:

> "Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and in me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines."[26]

> "[Readers]… should imbibe the fundamental truth that an organism is a tool of DNA rather than the other way around."[37]

The writing is clearly powerful, but is it meaningful? To show the lack of its empirical basis—beyond the statement "they are inside us"—Noble presents opposing paragraphs:

> "Now they [genes] are trapped in huge colonies, locked inside highly intelligent beings, moulded by the outside world, communicating with it by complex processes, through which, blindly, as if by magic, function emerges. They are in you and me; we are the system that allows their code to be read; and their preservation is totally dependent on the joy we experience in reproducing ourselves."[12]

> "The fundamental truth is that an organism is the only tool by which DNA can express functionality by which the book of life can be read. DNA alone is inert, dead."[12]

This new framing changes the script, so to speak. Now, organisms are the masters and genes are tools used to forward the organism's aims. If a cell

loses its DNA, it persists to live until that DNA is needed to replicate or another vital function from it is needed. Without a cell, however, DNA is lifeless. The fact that this scenario can be portrayed both ways without issue shows that Dawkins' portrayal is mere imagery without substance. He has not proven one-way causation or subservience to genes, he has poetically described it. In response, Noble poetically described the opposite.

To decide which, if any, scenario is true, a controlled experiment would be useful. According to Noble, however, such an experiment is impossible.[12] As mentioned earlier, the only empirical statement in Dawkins' passage that Noble identified was that genes "are in you and me." This is agreed upon by both parties. The rest is illusory and not falsifiable through experimentation, a fact which should raise alarm bells for humanist empiricists when they come across it. Noble expands upon this point, writing, "Selfishness cannot be defined as an intrinsic property of nucleotide sequences independently of gene frequency. It is a strange hypothesis that uses its own definition of its postulated entity as its only prediction."[22]

What evidence is there of genes being causal, selfish entities in the first place? An organism may have agency, but as Noble writes, "A gene cannot be selfish if it simply part of something else that is the purposive entity — the organism. Only the purposive entity could be considered selfish. Genes do not and cannot make choices; organisms can and do."[23]

Paint on an artist's palette cannot create a painting on its own. Nor can it have agency or desire. Nor can it have choice. And if it has neither power, nor desire, nor agency, nor choice, it cannot be deemed selfish in any literal sense. It can be considered unthinking, mechanical—an instrument, but not an agent. Noble continues, "In this sense of being used by the system, genes are not agents in causality; they are templates, tools enabling the organism to develop and function."[23]

Genes are not essential to every function of the organism. They are responsible for the initial production of proteins, but then so much occurs without the gene's knowledge or choice. The brain is one such example. The brain continues to develop late into adulthood, being constantly affected by external influences. No specific genes, or even combinations of genes, have been shown to dictate behaviour. If anything, we intuit the opposite—that our behaviours are the complex outcome of our genetic makeups, external stimuli, mental processes, and spiritual states. This is what all pre-modern societies, however remote from one another, seem to have concluded. That historical fact does mean that it must be true from a scientific standpoint, but it does show that we cannot presuppose the opposite. We cannot take for granted that one day we will discover the combination of genes that

is responsible for 'X', where 'X' may be whatever complex human process one may imagine.

When so much around us and within us affects our development and maintenance, it is incorrect to privilege only genes with causation. Therefore, the passive filter pillar of Neo-Darwinism is dismantled. Though, in fairness, it was not a difficult pillar to dismantle as it did not rest on any firm evidence in the first place. Its 'justification' arose predominantly from metaphor and imagery.

In 2009, Noble organised a debate between Lynn Margulis and Dawkins. Lynn was a well-known opponent of Neo-Darwinism, famously asserting that history would ultimately view it as "a minor religious sect of the twentieth century within the extensive religious framework of Anglo-Saxon biology."[38] Margulis was an award-winning scientist whose groundbreaking research on symbiogenesis received significant recognition from the scientific community. Her work challenged Neo-Darwinism and so it was downplayed by them when she was rising to prominence.

One very notable fact that came to light in the debate between Margulis and Dawkins is the very ephemeral and poorly demarcated definition of the word 'gene' in Dawkins' works. When Margulis stressed that character inheritance involved more than just strands of DNA, Dawkins retorted, "I would embrace that gladly as a new 'honorary' gene. That's fine."[39] The audience could be heard groaning at this and Dawkins responded, "Why not? Why not?"[39]

Danish geneticist Wilhelm Johannsen argued that a gene was not a strictly defined physical entity per se, but a 'unit of heredity' that determines specific traits.[40] Noble claims that Dawkins' can be seen to employ this definition when it suits, not appreciating that the definition violates his claims in *The Selfish Gene*, which presupposes and describes genes as distinct strands of DNA—chemical entities, actors. Switching between definitions when pressured is disingenuous, and it belies an internally inconsistent belief system that needs addressing.

Perhaps it is done unknowingly by Neo-Darwinists, or perhaps more malevolently, but the fluid use of the word 'gene' has not gone unnoticed. Gregor Mendel showed that inheritance can be understood as traits belonging to distinct units which had a probabilistic chance of being transmitted to a future generation. This is a far cry from the contemporary usage of genes employed by Neo-Darwinists when they feel cornered. Such a wide and ever-expanding definition of 'gene' is both useless and evidence of a growing gene-of-the-gaps theology. Noble writes:

> "But the gene of Mendelian genetics is very different from the concept used by those who study genes today. Significantly, it is different from that used by Dawkins in his book *The Selfish Gene*, which changes from context to context. In fact, the gene as a concept has become slippery, like a conjurer's sleight of hand. One moment it is an independent inherited characteristic; the next, it is a DNA sequence. But these are not identical, and confounding the two creates a conceptual muddle."[41]

Failing to properly define then adhere to a single understanding of the term 'gene' is fatal for Dawkins' theory. A vague idea of a gene as anything that is inherited is a nice idea but in direct opposition to the selfish gene concept, in which a physical entity, a past master, is ruling over each organism. Furthermore, if we consider a gene to be anything that is inherited, then Dawkins' whole argument about causality becomes circular. In Noble's words, "The circularity of this argument is apparent. If we end up saying a trait is a gene, then the concept of a gene as a causal factor in a trait is meaningless."[23]

Anyone that carefully and critically reads Dawkins' work will see the tautological nature of his definition of genes. If we wish to discuss genes as physical entities and not metaphysical concepts or abstract processes, then we must be consistent. A serviceable definition could be: a segment of DNA (or RNA) that codes for a function(s) and occupies a fixed locus on a chromosome. If one wishes to refer to this string of protein as a 'unit of inheritance', that is okay, but to say that a gene is 'everything that is inherited', and not a strictly defined physical entity, causes Dawkins' narrative to collapse internally.

Inheritance as a concept is an abstract process, not a measurable entity. For a physicalist like Dawkins, any talk of a 'master' that is an abstract, non-physical entity should be ontologically unsettling. Noble describes inheritance as follows:

> "Inheritance is a process, not a discrete, measurable entity. What we inherit is a propensity to do things. So we inherit not in two discrete parts, cause (gene) and effect (trait). We inherit a capacity of becoming or being, where cause and effect are one, as in generating heart rhythm."[23]

In truth, the word gene has not been well-defined for some time by Neo-Darwinists. This conceptual muddle Noble speaks of has persisted and obfuscated margins, allowing them to persist in purporting their con-

flicting doctrines. Another of these paradoxical doctrines is seen in the personification of genes as thinking, desiring actors which utilise bodies to achieve their aim of self-preservation. Ignoring the absurd idea of genes having thoughts and feelings for a moment, we are still faced with the issue of an arbitrary precedence having been given to genotypes over phenotypes. This narrative forwards genes as active players, while phenotypes are seen as passive. Noble writes, "It is a curious fairy tale in which genes are selected, phenotypes are not. The story came with a fantasy land called the 'gene pool'. Yet it is the phenotype that acts in nature."[23]

Even the concept of 'gene pool' is problematic and poorly understood. The broad-strokes understanding is that there exist a definite number of genes within a population at large, and that these genes correspond to the myriad phenotypes within the population. Natural selection favours those genes that offer survival benefits, leading to them being passed on to future generations. Whilst phenotypes are significant in the practical story, they are insignificant as far as causation and agency are concerned. In Dawkins' own words:

"We are all survival machines for the same kind of replicator-molecules called DNA. But there are many different ways of making a living in the world, and the replicators have built a vast range of machines to exploit these ways in order to survive. A monkey is a machine that preserves genes that enable it to go up trees, a fish is a machine that preserves genes so that it can live in water; there is even a small worm that preserves genes in German beer mats."[26]

This gene-centrism leads to the impression and belief that genes are the sole determinants of traits—that they dictate phenotypes. It is a belief that has become so entrenched within our collective understanding that it often goes unchallenged and unexplored. The reality is far more complex, and frankly, far more beautiful. Genes do not exist in a vacuum; they are influenced by the environment, by other genes, and by all that surrounds and communicates with them. This influence makes causality a difficult thing to ascribe based on simple notions of unilateral chains of command (genotype to phenotype).

Modern discussions on evolution have largely centred around gene frequencies, and while this is an important part of the evolutionary process, it is not its entirety. These discussions oversimplify the intricate web of interactions that contribute to an organism's development and adaptation. To coin a metaphor, one may study the numbers on a grandfather clock very closely, looking carefully at their arrangement, sequence, size, font, and so on, but if they fail to observe the whole picture, noticing also the moving hands, the pendulum, and the intricate wooden carvings, they would fail

to understand the clock's purpose and function. The numbers are important—essential, even—to accurate timekeeping, but they are not the only aspect of the clock that matters. Consider, for example, that by studying the numbers only, one may fail to appreciate that this grandfather clock's function is also to beautify whatever room it is placed in—perhaps that is even its primary function, and the owner could not care less whether the time on the clockface was accurate or not.

A trait emerges—much like the grandfather clock—from a combination of elements. These include genetic, environmental, and developmental factors. Excessive gene-centrism oversimplifies the biology of organisms, and a more holistic understanding is in order if we truly wish to understand the organic world.

This mechanistic reductionism we see in the mind of Dawkins and those like him is nothing new. It is a wish to reduce anything and everything to simple physical processes. It was the belief of classical rationalists that the world could be explained through a system of levers and pulleys—a mechanical, inorganic theory of everything. Among this group were theists, such as Descartes, who justified the mechanism by arguing that the physical world and the spiritual world were two completely separate entities. Descartes' dualism is now famous and known to many. Others, such as Spinoza, were atheists who disregarded the presence of anything non-physical.

Descartes' wrote:

> "If one had a proper knowledge of all the parts of the semen of some species of animal in particular, for example of man, one might be able to deduce the whole form and configuration of each of its members from this alone, by means of entirely mathematical and certain arguments, the complete figure and the conformation of its members."[42]

Historically, this mechanism held out as a popular philosophy for a few decades before Newton brought along ideas of gravity, fields, and forces. Newton identified a mysticism in the world and wrote "*hypotheses non fingo*" [I frame no hypotheses].[43] No theory—be it the string theory or that of quantum physics—can truly explain how things attract without ever touching, and the more one delves into the minutiae, the more mystical the world seems. Dr Allan Chapman, Fellow of Wadham College and faculty member at Oxford University History Faculty, wrote the following:

> "As a concept, however, Newton's recognition of the ultimate unknowableness of the nature of gravity was to have an immensely

> liberating effect upon subsequent science, as future generations of scientists no longer saw themselves as having to explain the powers of nature (such as light, electromagnetism, or by the 1840s, energy itself), but rather as free to explore their physical properties and to establish exact mathematical expressions for the same. For it came to be accepted that it was the scientist's job to describe nature and to elucidate nature's laws, and that it was the task of the theologian or the philosopher to explore why these laws were so."[44]

Thus, reductionism and mechanism are no new phenomena. In our era, the more difficult questions are often not thought about deeply at all, and instead a pragmatic approach to worldly aims is utilised. Dawkins' is very much in the atheist, reductionist camp, and that explains a lot of the fierceness with which he defends what seem like lost causes or insignificant positions.

What has changed from the old reductionist argument to the new one is that people no longer attribute causation to sperm, instead attributing it to DNA, to which they also attribute control. For Noble, there are stark similarities between the dualism of old and the gene-centrism of today, "This separation of mind and body and the gene-centric view have something in common, which is that they both look for an organiser of something that is in fact self-organising: the organism."[23] The dualism of old has morphed into a new dualism, where we have a lifeless body and a living genome instead of a lifeless body and a living soul.

It makes little sense to adhere with any strictness or literalness to Dawkins' narrative when one can clearly appreciate that the conditional logic of life forms is found outside the genome, in the cell membrane and beyond. The genome interacts with, and is dependent upon, all that surrounds it. This is less a picture of dualism and more a picture of symbiosis.

CHAPTER 5

Replication and Causation

Another issue that Noble found with Dawkins' selfish gene theory was that of self-replication. To appreciate this, let us return to a time before that of Watson and Crick's discovery of DNA, when a young Erwin Schrödinger was presenting ideas that would go on to shape physics and biology in the following decades. Schrödinger's 1944 book, *What Is Life?*, made a number of predictions about the nature of life. Two of these predictions are as follows:

i. The information and processes required to sustain and transmit life are sufficiently complex to require huge numbers of entities working together .In other words ,information storage and transfer would have to be at a molecular—and not a tissue or organ—level for it to work in humans.

ii. Genetic replication is akin to aperiodic crystallisation.[45]

To quote Schrödinger himself:

> "Thus we have come to the conclusion that an organism and all the biologically relevant processes that it experiences must have an extremely 'many-atomic' structure and must be safeguarded against haphazard, 'single-atomic' events attaining too great importance. That, the 'naïve physicist' tells us, is essential, so that the organism may, so to speak, have sufficiently accurate physical laws on which to draw for setting up its marvellously regular and well-ordered working."[45]

> "To give the statement life and colour, let me anticipate what will be explained in much more detail later, namely, that the most essential part of a living cell – the chromosome fibre – may suitably be called an aperiodic crystal."[45]

These two hypotheses have been accepted by Dawkins—in some form or another—and rejected by Noble. The latter argues that the sheer enormity of information contained within an organism is the reason it cannot all be stored at a molecular level. Instead, there is a large, interconnected entity that utilises other parts of the cell to store information. Beyond that, tissues, organs, and even organisms interact and support one another, passing information along the way.

And as for the aperiodic crystals, Noble is in staunch disagreement. Crystals form lattices through further expressions of the same base structure. They can do so due to their molecular structure permitting further crystallisation, and as the process is expansive and not consummatory, it is—at least theoretically—indefinite. They may have translational symmetry (i.e. be periodic) or not (i.e. be aperiodic). This is not how humans replicate. This process is more in keeping with growth and expansion than with replication.

Even in terms of control and causation, the processes are starkly different. Noble explains:

> "Once seeded, crystals grow automatically. DNA inside a cell does not. Nor can it do outside a cell. This is fundamentally different from crystallisation, since DNA replication is under the active control of the living cell. Unlike a crystal, the process is not inherent within the DNA itself. The cell controls DNA."[23]

Beyond the lack of control is the sheer difference in complexity between human replication and aperiodic crystallisation. Schrödinger's rudimentary understanding of replication was pervasive, however, and it affected Neo-Darwinists like Dawkins, who mentioned that DNA replicates like a crystal in *The Selfish Gene*.[26] Unlike many of these latter thinkers, however, Schrödinger was less polemically minded and so he realised there were a number of problems in his framing—most notably is the absence of free will and the mind, the existence of which is more easily intuited than the existence of logic itself, let alone the logic of any specific argument against will and mind. Consider the following couple of quotes by Schrödinger:

> "We seem to have arrived at the ridiculous conclusion that the clue to the understanding of life is that it is based on a pure mech-

> anism, a 'clock-work'… The conclusion is not ridiculous and is, in my opinion, not entirely wrong, but it has to be taken 'with a very big grain of salt… Our [Western] science has cut itself off from an adequate understanding of the Subject of Cognizance, of the mind. This is precisely the point where our present way of thinking needs to be amended, perhaps by a bit of blood-transfusion from Eastern thought."[45]

Noble argues that the grain of salt Schrödinger was alluding to was meant to avoid the reductiveness of the central dogma we discussed in Chapter 2 (i.e. the hypothesis that organisms are incapable of changing their own genetic makeup, making causation unilateral and not allowing for the possibility of the environment to affect genes).[23] Noble forwards three beliefs about genes that have prevailed—in a loose but still meaningful form—since Schrödinger's time until ours that he feels are mistaken:

i. genes have the capacity for self-replication;

ii. genes replicate with a high degree of accuracy; and

iii. accurate replication is the sole purpose of life.[23]

Noble counters these three beliefs with three of his own:

i. genetic material does not self-replicate—it depends on the cell for replication;

ii. genetic material does not replicate accurately—the faithfulness of its replication is dependent on the cell; and

iii. accurate replication is not the purpose of life—it is responding to change.[23]

To fully appreciate the first two beliefs and counter-beliefs, we need to look at least a little deeper at the mechanism of DNA replication. Does DNA replicate independently or dependently? And if it does so independently, then does it replicate with sufficient accuracy to sustain a species? Before we delve into this, remember that no one is arguing—at least no one should be arguing—that DNA is primordial in any metaphysical or meaningful way. Even the atheist humanist physicalist would not think as much, as they attribute no metaphysical value to DNA and RNA over their precursors. Nor can they attach meaning—if they wish to stay internally consistent—to any one stage in the journey from the big bang to the primordial soup to

the animal kingdom. Their argument is a more superficial one that rests on certain philosophical presuppositions we needn't discuss here.

During cell division, DNA replicates with remarkable accuracy, but it does not do so independently. This process is facilitated and overseen by the cell apparatus. The cell facilitates replication by aiding and assisting DNA in repairing errors, whilst it oversees replication by ultimately destroying the DNA if an error is deemed too significant. This latter point is important, because if the cell can destroy DNA that is irreparably damaged, then the DNA is hardly the master of their relationship. Why would DNA 'want' to kill itself? One may suggest that a DNA strand would wish to do this in order to preserve the DNA as a collective species, but this would be nothing more than metaphor and symbolism. A 'species' is an abstract entity, and a blurred one at that, whilst a DNA strand is a physical entity. Thus, for a nominalist humanist, this argument is of little polemical value—that is, of course, if they wish to stay internally consistent.

Looking at DNA replication more closely, we begin to appreciate just how much DNA relies on other parts of the cell. However, even if we were to ignore that, it would be difficult to ignore the reparative properties of the other cellular components. Without this external support, the error rate of DNA replication is around 1 in 10^{4} nucleotides incorporated.[46] This error rate is too high for the safe propagation of a species, and so external proofreading and error-correction mechanisms are utilised, bringing the error rate down to around 1 in 10^{10} nucleotides incorporated.[47]

At times, Noble leans heavily on the work of James Shapiro, American evolutionary biologist and professor in Biochemistry and Molecular Biology at the University of Chicago. On a personal level, I [Subboor Ahmed] had the great privilege of interviewing James Shapiro about the agency—or lack thereof—of cells. During our discussion, he stated, "… [the cell] needs the proteins—it needs nucleotide precursors as well—I mean it's not just accurate transcription, it's any transcription or replication at all. It's dependent upon the cell. The idea that the genome is somehow independent of the cell doesn't make sense."[48]

Schrödinger's very big grain of salt was justified, it appears, as the unilateral causation described by the central dogma is undone by the top-down causation of the transcription and proofreading systems found within each organism. The details are worth reflecting over in light of contemporary findings in molecular biology. Each double helix of DNA is structured to store as much information in a small a space as possible, whilst permitting the replication and 'reading' of this information. Each strand within the DNA double helix is coded sequentially with one of four nucleotides: A (adenosine), T (thymine), C (cytosine), and G (guanine). The A and T

nucleotides pair, and the C and G nucleotides pair. The opposing strand within the helix is coded sequentially with opposing nucleotides. In RNA, there are no T nucleotides; instead, there are U nucleotides which fulfil a similar function.

The figure above demonstrates this base pairing of nucleotides. It is perhaps worth mentioning that reality is never quite so simple, and so there is a lot that we are brushing over to simplify the problem. Nevertheless, it is accurate to say that the double helix is unravelled and re-ravelled to produce complementary strands based on their own sequence of nucleotides, and it is worth understanding this process in at least a little more detail. A simplified overview of the process is as follows:

1. Opening of the double helix.

    a. The two strands of DNA which coil to form a double helix first need to be separated.

    b. This begins at a point in the strands known as the 'origin'.

    c. An initiator protein unwinds a short segment of the double helix before a helicase enzyme comes to separate the strands further. It does this by breaking the hydrogen bonds which form between the opposing bases on the DNA strands, allowing them to move apart.

2. Priming of the template strand.

    a. Meanwhile, an enzyme known as primase attaches to each of the separated DNA strands to begin the replication process.

   b. Primase forms a primer, which is a segment of consecutive nucleotides that can be added to form a new strand of DNA.

3. Assembly of a new DNA segment.

   a. By now we have an unwound segment of DNA with a primer molecule attached at the point replication should initiate.

   b. DNA polymerase, another enzyme, wraps itself around the strand of DNA and sequentially adds nucleotides to a complementary strand.

   c. Due to the complementary nature of the base pairs (A always matches T and C always matches G), the new strand added to each of the separated strands should be identical to the one they lost initially.

   d. The nucleotides that are used to form the new strand are found freely floating in the cell nucleus.

However, this process is error-prone—relatively speaking—and a few examples of these errors are as follows:

1. Incorrect nucleotide added.

   a. Complementary base pairing means that A nucleotides are always paired with T nucleotides, and C nucleotides are always paired with G nucleotides. However, there are times when the 'wrong' nucleotide is added to a sequence and it is unable to pair effectively with the nucleotide opposite to it in the double helix.

2. An extra nucleotide is added or skipped.

   a. The new strand of DNA may contain an additional nucleotide that does not fit into the sequence, or it may have a missing nucleotide, leading to frameshift errors.

3. Environmental damage.

   a. Environmental insults, such as radiation or chemical injury, can lead to damages within DNA strands.

   b. These are varied and the outcome depends on the nature of the injury.

To account for these potential errors, proofreading and repair mechanisms have been built into the cell:

1. Proofreading through DNA polymerase.

    - Each DNA polymerase enzyme is able to proofread its own work. When a nucleotide is added, the polymerase aims to check that this nucleotide is correctly paired with its opposing nucleotide. If this is not the case, then the incorrect nucleotide is replaced with the correct one.

2. Mismatch repair.

    - After the polymerase has done its own proofreading and replicating of the new strand, specific mismatch repair enzymes arrive to double check the accuracy of the new DNA strand. Any errors that are identified are corrected at this stage.

3. Base excision repair.

    - DNA glycosylases initiate base excision repairs for errors they identify. This means that the base is removed before being replaced by a new one that fits better into the sequence.

4. Nucleotide excision repair.

    - If the damage is more substantial, and a base excision repair deemed insufficient, then a nucleotide excision repair is carried out, in which a nucleotide is removed and then replaced with a new one that fits better into the sequence.

Regarding this quite extraordinary proofreading process, Noble writes:

> "DNA sequences are thus corrected one by cellular mechanisms that would outperform even the best human copy-editors. Imagine a copy-editor working almost word-perfect through the texts of hundreds of books. Nature took a couple of billion years to evolve such a magnificent trick. It is a trick that turns on its head the idea that genes control cells. The organism itself controls this remarkable spectacle. The genes dance to the tune of the cell."[23]

Without the proofreading and repair mechanisms of the cell, the genome would quickly accumulate hundreds of thousands of errors, leading to dysfunction and death. These corrective processes occur many millions

of times over to ensure that an organism remains viable. Further, DNA replication is not the same as reproduction—an entirely different process. When a cell replicates through mitosis, it produces complete clones of its current DNA strands using the method outlined above. Each parent cell produces two identical, diploid cells with a full complement of DNA.

During sexual reproduction, however, organisms do not preserve their own DNA in an intact form. Far from the power-hungry, self-preserving overlords described by Dawkins, these genes unintentionally split and mix with other genes. To produce gametes (sperm and egg cells), parent cells duplicate their genetic material then undergo two rounds of cell division. The result is four non-identical, haploid cells. These then pair with gametes from other organisms of the same species to produce a new organism within the species with a full but unique genome.

Throughout this entire process, correction methods are in place to prevent errors and to repair errors if they do arise. A strand of DNA's double helix structure may make it easy for the proofreading and repair mechanisms to work, but it is not commanding the process. Noble writes, "All this serves to demonstrate that the conceptual separation of replicator and vehicle leads to erroneous assumptions about what natural selection acts upon — because, where the replication takes place, it is a cellular and organ process."[23]

During their public debate, Noble pointed this fact out to Dawkins, who quite evidently dodged the question. His aversion to directly addressing the problem is telling. Noble mentioned the above facts about the proofreading and repair processes, arguing that they are carried out by the cell, the vehicle for DNA. He argued that without this vehicle, the error rate would be far too high to sustain life in an organism with as complex a genome as our own, and therefore, to separate the replicator from the vehicle is logically unsound.

Dawkins' response amounted to a sidestep and simply repeating his original statement about genes being selected in a gene pool. Noble responded, saying:

> "I fully understand what you're saying, Richard, but I don't think you really answered my point, because, you see, I was saying that none of that would happen without the cooperation, at the least—and I would say the very active cooperation—of the living cell, because, as I said, it's only a living cell that can reproduce accurately."[12]

Dawkins never went on to address this challenge, leaving it to cast serious questions on his selfish gene paradigm. This side stepping, prevaricating, and obfuscating took up a large part of the debate. Whenever challenged on a seemingly irreconcilable aspect of his theory, Dawkins reverted to restating his pillars or speaking on something else. There was little direct engagement with the scientific or philosophical questions posed by Noble. No wonder Dawkins wished for the meeting to not be called a debate. Noble went on to later state that Dawkins is a good rhetorician but not skilled in actually engaging with challenges. During an interview with Curt Jaimungal, Noble said:

> "He is a rhetorician, yes. He is a very clever debater. I think he doesn't know the detailed molecular biology that I was referring to, and so I think he went off in a different direction. Let me just give just one example of that. I point out that his test for whether a gene was causal or not was to measure its association with whatever it is thought to be the cause of. So, if you think you have a gene that produces cancer, you ask how well strongly associated is that gene with cancer. And I said look, the problem with that, Richard, is that you're using a word, 'cause', in a different sense, because you're talking—or giving the impression—that it is an active cause, in the sense that molecules are bumping into each other, actively interacting with each other. There are many forms of 'cause'.
>
> DNA is not an active cause was my point. And the reason is that it is not like proteins. Proteins are active causes; they actually do things. They are enzymes. They make reactions occur that would otherwise not occur. DNA does none of that. It's simply a form. It is a pattern, if you like, which gets used by the protein-making machinery of the body to create a protein. It doesn't, itself, actively do that. It's the ribosome in the cell together with all the various processes there that enable proteins to be made that interpret that form.
>
> Now, many years ago—over 2,000 years ago—one of the earliest Greek philosophers, Aristotle, made this point. There are fundamental differences between causation by shape, causation by form, causation by physical interaction, and causation by final cause. Those are at least four forms of causation. They are all fundamentally different. Now, I don't know why, but he didn't seem to see that. He just simply said, 'Well, but Denis, they are active causes.' I had already made the point that a form is not a

> cause in the same sense that molecules bumping into each other are. There are different forms of causation." [6]

Following the debate, Dawkins fell conspicuously silent on the issue and mentioned that he would address it in his forthcoming book, *The Genetic Book of the Dead*.. This book, released in October 2024, contained a chapter in which Dawkins restated his position and failed to address the studies that Noble had produced as evidence for his view. The issue of proofreading was not even addressed properly.

During my [Subboor Ahmed] interview with Shapiro—the academic I referenced earlier—I brought up Dawkins' response to the proofreading and repair issue, asking for Shapiro's take on the matter. In particular, I wanted to know what Shapiro thought about Dawkins' claim that the proofreading and repair processes do not significantly detract from gene-centrism, as whether these processes exist or not does not undermine the central fact that genes created us—body and mind. Shapiro replied:

> "Well, I think he's not thinking biologically. The genes are—the genome is—a database. It has to be properly replicated. It has to be properly read. It has to be properly interpreted. And there are some things which are not specified in the genome, such as the structure of the cell envelope. And the genome itself is not sufficient information to determine the entire reproduction or growth of an organism. It's simply, as I said, a database so that you can make the proper proteins and RNA molecules that are needed for reproduction."[49]

The processes we discuss now so axiomatically were not known in the early stages of evolutionary biology. The field has advanced significantly, and holding on to old axioms is neither helpful nor wise. 'Causality'—if we are to personify components of organisms—is not unilateral. There are many causes—and many forms of causes—occurring simultaneously. To hold that DNA is independently causative is by now, a clear absurdity.

And if one thinks more deeply, they realise that all this physicalist interpretation still does not reach the more serious question about causality that we all experience:

"Consciousness cannot be accounted for in physical terms. For consciousness is absolutely fundamental. It cannot be accounted for in terms of anything else." [50]

It is beyond the scope of this book to explore the topic of physicalism and consciousness, as this requires a separate volume. I predict that some of the ideas discussed here will need to be revisited when addressing that issue.

CHAPTER 6

Reorganising DNA Dogma

DNA is stored in the nucleus of a cell. This fact alone—that so much information can be stored in such a small space—is remarkable. Whilst some infer a teleology from this, others aggrandise the DNA strands themselves, seeing them as control centres for all else. Dawkins wrote, "DNA neither cares nor knows. DNA just is. And we dance to its music."[51]

In reality, the cell organises itself and uses the DNA as a template to produce new proteins essential to the proper functioning and preservation of the organism. Regarding the role of DNA as a command centre, code, and organiser of the organism, Noble wrote:

> "'Code' is a metaphor, 'organiser' is simply wrong. It is the cell that organises itself. It is the organism that parcels out its DNA in the form of its chromosomes to pass those tools on to the next generation. Furthermore, organisms may share the tools. Perhaps the real secret was that we failed to see this. The focus on DNA as a code may be why this was so."[23]

Cells are remarkable little factories that can produce the amino acids required for life from four basic building blocks: A, T, C, and G nucleotides. These nucleotides form codons, which are trinucleotide sequences that 'code' for specific amino acids. Amino acids join via peptide bonds to form proteins. A total of 20 amino acids are used within the body, and they are all produced through combinations of nucleotides. The 20 amino acids join in various ways to make a huge variety of proteins, all the way from enzymes to structural proteins.

We use letter representations of nucleotides to simplify the process for our minds. This biological algebra is useful to communicate and manip-

ulate the DNA templates of interest. In nature, no such code exists. The molecules combine and uncombine as a response to the physical processes exerted upon them. These combinations reflect organic limits and forces in nature. Noble writes:

> "It might be appealing to see all the letters of the DNA sequence appear on a computer screen, but that is not how the cell sees it or uses it. No cellular site-foreman opens the 'blueprint' on a table from which he then builds the cell. The DNA base pairing is simply an essential chemical fact."[23]

Nature operates according to the laws and limitations of physics and chemistry. Cells 'reorganise' base pairs and use them to produce the materials of life. But if DNA isn't a control centre, then what do geneticists do all day? Is their job not to find genes that cause particular processes to take place or lead to particular diseases? A common belief is that this is precisely what geneticists do; a more accurate belief is that this oversimplification is useful at a lay level but incorrect at a technical one. In reality, relationships between genes and conditions are complex, multifactorial, and, at times, mercurial.

At times, the link between a genotype and a phenotype is apparent, direct, and clear. As discussed at length before, this still does not mean that causality is a one-way process. However, what is overwhelmingly the case with regard to phenotypes and genotypes is that there is no such strong link. Most conditions are clearly multifactorial ones, with multiple genes and multiple non-genetic factors predisposing individuals to them. Thus, the outcomes are probabilistic, and large numbers of study participants are needed to identify relationships. If we need such large data sets to even identify relationships, then how are genes supposed to interpret the same? Noble explains:

> "Cells could not translate DNA in such a probabilistic way. DNA is engaged in the cell's biochemistry rather than in probabilistic calculations. A particular DNA sequence might indicate a disease risk in the population or for a given individual with that profile. Still, it is one of many possible such outcomes."[23]

Thinking of genes as simple codes for traits is fraught with danger. From the outset, it imposes upon the molecular world an understanding foreign to it. It is our conscious minds that think in terms of unilateral cause and effect—as we do in so many fields of study—and we like to see the world in black and white. However, the world is polychromatic, and genes are

multifunctional. Depending on the need of the organism, the same string of DNA can be used in many different ways. To quote Noble again:

> "Treating DNA as a code misrepresents how cells use genes. How a gene is used or expressed may vary with the functional context. Genes are multipurpose. Indeed, many geneticists favour an 'omnigenic theory', where all genes are involved in most, if not all, functions."[23]

The omnigenic model goes to show just how complicated the genotype-phenotype relationship is. The model was introduced through the work of geneticists such as Ben Barres in his article, *The Omnigenic Model: A New Framework for Understanding the Genetics of Complex Traits.*[52] It suggests that complex traits, such as height, are not dictated by a single gene. Rather, multiple genetic influences determine such traits, giving further credence to a more holistic understanding of how the genome works. Complex genetic and extra-genetic factors influence and facilitate outcomes. There is no instruction manual to be found within genes. Instead, we get strings of data that may be interpreted and read in different ways depending on wider contexts.

Integrating the omnigenic model with Noble's views of genetics is a straightforward process. Genes provide information that is interpreted by the cell—which itself interacts with other genes and the external environment—to produce proteins for bodily functions, as per the organism's needs. These proteins go on to form a part of the environment that feeds back to the cell and guides further development. A large and interconnected network is formed between components within the organism, and this leads to a symbiosis that facilitates and propagates life.

Integrating the omnigenic model with the central dogma of Neo-Darwinists is difficult, if not impossible. Recall our earlier definition of this pillar, 'the hypothesis that organisms are incapable of changing their own genetic makeup, making causation unilateral and not allowing for the possibility of the environment to affect genes'. It is the belief that the DNA-RNA-protein pathway represents a unilateral and singular pathway of information exchange within organisms. Genes are considered a driving force, not stores of information, and cells and organisms are considered passive puppets in the process. In this paradigm, it is difficult to find room for any genes affecting and overpowering others, and it is difficult to accept that external influences, such as the cell environment or surrounding proteins, can affect one's phenotype and even the genes within their DNA. Epigenetics is seen as an inconvenience that must be ignored in all but lip service.

‘Central dogma’ is an interesting term, though it is not a polemical one conjured up by opponents of Neo-Darwinism. The term was invented by Francis Crick regarding his own theory. Consider the following quote by Crick, along with the response by Noble, and you will appreciate how something so untested can be accepted as dogma by a wide range of scientists. We all-too-often forget that scientists are entirely human and their theories and polemics are never divorced from their humanity.

Crick wrote:

> “I called this idea the central dogma, for two reasons, I suspect. I had already used the obvious word hypothesis in the sequence hypothesis, and in addition I wanted to suggest that this new assumption was more central and more powerful… As it turned out, the use of the word dogma caused almost more trouble than it was worth. Many years later Jacques Monod pointed out to me that I did not appear to understand the correct use of the word dogma, which is a belief that cannot be doubted. I did apprehend this in a vague sort of way but since I thought that all religious beliefs were without foundation, I used the word the way I myself thought about it, not as most of the world does, and simply applied it to a grand hypothesis that, however plausible, had little direct experimental support.”[53]

Noble responded:

> “Crick’s statement is shocking. It shows that many scientists ignore the rigour of philosophical analysis, and also scientific method. Yet it provided a false foundation for the gene-centric view of function and evolution. Whatever thought one has about that method, testability via experimental support is a crucial ingredient of science. Simply holding onto ideas as dogma regardless leads to other errors in thinking. Indeed, imposing such a doctrine has the harmful effect of preventing theories and hypotheses that counter it. Those who have proposed an alternative perspective have been regarded as heretics. Yet what Crick said is true: ‘there is ‘little direct experimental support” for the Central Dogma, and the contrary evidence was there to be seen. This dogma is where the resistance to understanding organisms as creative agents in their lives and in evolution has arisen. This is how science gave agency to genes but denied it to organisms.”[23]

Thus, the central dogma was established decades ago with little direct empirical evidence for it. From there, it was accepted and it continued to perpetuate, without anyone seriously questioning its truthfulness. Due to its polemical utility and dogmatic nature, fervent believers in the theory have resorted to denouncing those who oppose it and stifle discussions. This has persisted despite decades of advancement in molecular biology.

One such advancement has been the discovery of reverse transcription in retroviruses such as the human immunodeficiency virus (HIV). Reverse transcription was identified in the 1970s as an alternative method for the production of proteins. Instead of DNA, RNA molecules were shown to be 'responsible' for the production of proteins. These molecules would insert into host DNA before changing the host's genome and forcing it to produce proteins. For the virus, its RNA provided all the genomic material it needed. This process is in direct violation of the central dogma, and though it has been accepted as fact by geneticists, many of them remain in cognitive dissonance by believing both the central dogma and reverse transcription to be true.

Further, we know that the regulation of gene expression is often carried out by the cell, and that the genome is often reorganised by the cell. These processes are, again, in direct contradiction with the central dogma. Yet the dogmatism persists.

Some argue that unilateral causation is evidenced by the fact that reverse transcription does not occur from proteins back to DNA. They claim that proteins cannot be used to determine a specific DNA sequence. There is some truth in this, but the claim does not entail what they believe it entails. It is true that proteins do not transcribe genes—that level of circularity would be unnecessary. However, proteins do not need to do this in order to affect gene expression and organism phenotype. Noble explains:

> "[The central dogma is] based on the idea that the transcription process from DNA to protein cannot work backwards. But the cell does not need to do this to alter the genome. In one sense, it merely needs to allow changes to occur, as it can, for example, by varying the error correction process, or by large-scale chromosome and genome rearrangements, and then choose between the variants."[23]

To designate transcription as the only causal mechanism, and to then designate its direction as the only direction of causality is baseless. In reality, there are many mechanisms employed by cells and organisms to adapt to external stimuli and challenges. B cells, for example, produce antibodies that undergo somatic hypermutation when facing novel pathogens. This

process involves ‘intentionally’ mutating certain genes until an appropriate antibody is formed, enhancing the effectiveness of the immune response.[54] B cells also engage in isotypic commutation, tailoring their immune response to what is most needed by switching the type of antibody they produce.[55]

Similarly, T cells are able to modify their own DNA. They undergo clonal expansion after recognising specific antigens, leading to the proliferation of cells that can target that antigen. Memory T cells also form following infections, carrying modified DNA that encodes for specific receptors and enables a faster, more robust response to re-exposure of the same pathogen.[56] Noble uses the SARS-CoV-2 pandemic to illustrate this point further:

> “Now that sequence, from knowing the DNA to the RNA to the protein, tells you nothing about what controls the DNA. We now know that an army of RNAs do so. Where are they generated? They’re generated by the epigenetic processes in our cellular, organ, and tissue structures, which are, in effect, telling the genome what to do. Worse than that, they can do something which the Neo-Darwinists don’t like at all—change the DNA.
>
> Just ask what was happening during the pandemic. Our immune systems encountering a coronavirus they’ve never seen before—let’s forget about vaccines for a moment; just look at the natural process. Our immune system, recognising there was a new invader, was busy telling the immune system cells, ‘Please mutate as rapidly as possible in just that part of the genome that creates the grabbing part of the immune globulin’—that’s the protein that grabs the virus—‘Create a million new versions. Then we will select the one that grabs the virus.’ That’s precisely what the immune system does. It changes the genome. It is not supposed to be possible—happens all the time!”[12]

Barbara McClintock ,Nobel prize laureate and mentor to Shapiro ,identified another way in which cells manipulate genes .McClintock struggled to publish her work in the 1930-1950s due to the pushback she received from the Neo-Darwinist faithful .Recall the random error pillar’ :the hypothesis that evolution occurs through minor random alterations in genes that are passively favoured through a process of natural selection .‘The words’ passive ‘and’ random ‘are very important in that hypothesis .Why ?Because if a competing theory accepts that’ active ‘effort ,or’ choice ,‘arises from anything other than the DNA ,then it gives this other entity agency—a claim which would disprove the selfish gene theory and excommunicate one from their church.

The Neo-Darwinist view is that among the many, random, passive mutations in genotype, one offers the organism a survival benefit, which leads to that mutation proliferating. Neither the mutations nor the selection process is intentional or goal-oriented. McClintock was the first to disrupt this theory by showing how untrue that claim was. She recognised that the genome was dynamic and constantly changing in response to the environment and developmental factors. Looking closely at maize chromosomes, she showed that certain genetic elements—which she referred to as 'controlling elements'—could move around within the genome and affect how nearby genes are expressed.[57]

This process is now known as transposition. McClintock's controlling elements were able to insert themselves into new loci, leading to markedly different phenotypes. After many years of resistance, McClintock was able to publish her results, and in her Nobel lecture on 8 December 1983, McClintock said:

> "In the future, attention undoubtedly will be centred on the genome, and with greater appreciation of its significance as a highly sensitive organ of the cell, monitoring genomic activities and correcting common errors, sensing the unusual and unexpected events, and responding to them, often by restructuring the genome. We know about the components of genomes that could be made available for such restructuring. We know nothing, however, about how the cell senses danger and instigates responses to it that are often truly remarkable."[58]

This is yet another example of how cells instruct DNA .Noble mentions that each component within a cell can be viewed as a factory within a wider ecosystem of the cell.[23] McClintock winning a Nobel prize did not mean she was listened to by the Neo-Darwinists of her time ,or even of today. What she demonstrated ,quite clearly ,was survival mechanisms in which the cell controlled and changed the genome of an organism based on external influences .Think deeply for a moment about what this means—we are saying that the DNA ,that entity that is viewed by Dawkins as sovereign—is repeatedly changed by items over which it exerts no conscious or direct control .If that is not the very definition of passivity ,then there is no passivity in nature.

Shapiro ,McClintock's mentee ,had this to say about her delving into unorthodoxy to find answers that Neo-Darwinism could not accept:

> "The thing that sticks out most to me is how she empathised the enviable limitations of what she called the 'now' explanation—that means the explanation we have at the present moment for a phenomenon. And she said that we had to be aware, always, that we can never know what new ideas or phenomena will be discovered that can make an explanation irrelevant or misleading.
>
> And evolution examples include the existence of: [1] mobile and repetitive DNA, which she discovered originally; [2] horizontal DNA transfer between taxonomically distant organisms, which we discovered when we could sequence genomes; [3] Lego-like protein evolution by domain swapping, recognising the importance of non-coding RNAs in genomic and cellular regulation; and [4] rapid, large-scale genome rearrangements stimulated by chromosome breakage.
>
> These were all things which were inconceivable when I was a student in the 1960s, which we have learned about since then, and it really puts our assumptions underlying our thinking about evolution into a totally different realm."[49]

Shapiro continued the legacy of his mentor and was credited, in 1992, with being the first person to demonstrate natural genetic engineering, which he defined as "genetic change as a coordinated cell biological process, the reorganisation of discrete genomic modules, resulting in the formation of new DNA structures."[59] He showed that bacteria was able to rapidly transform their genomes in response to antibiotics through a mechanism known as natural transformation. They would obtain resistance genes from their environment, absorbing free DNA from dead or damaged cells. The adopted DNA may contain genes which offer a survival benefit, leading to the proliferation of that strain of bacteria. This way, multiple different species of bacteria develop antibiotic resistance. The new genome becomes a mixture of multiple genomes.

This is clearly at odds with the random error pillar of Neo-Darwinism that we mentioned earlier. Bacteria are clearly changing their genomes not through random errors but in direct response to their environments, which causes them to 'act' and make changes. Horizontal gene transfer—which can take place through conjugation or transduction—then allows bacteria to 'share' genetic information with each other. All of this allows bacteria to rapidly change genotypes in response to the challenges they face. Such rapid mutations and changes are at odds with the Neo-Darwinism that remains prominent to this day—an obstacle Dawkins did not manage to address effectively during his debate with Noble or in any subsequent writings.

From the pillars of Neo-Darwinism, the central dogma, passive filter pillar, and random error pillar have all been clearly disproven. The only one remaining is the Weismann barrier pillar, which is addressed in the forthcoming chapter. Whilst we do so, please remember that these alternative mechanisms of gene manipulation that we are discussing are by no means rare and non-representative. Regarding the 'backward' engineering of genomes—which is supposed to be impossible according to Neo-Darwinism—Shapiro wrote, "[I]t can be argued that much of genome change in evolution results from a genetic engineering process utilising the biochemical systems for mobilising and reorganising DNA structures present in living cells."[59]

Noble believes that this challenge was completely ignored by Dawkins during their debate, despite his attempts to get Dawkins to address it directly. Noble even referenced a study which demonstrated the swapping of entire protein domains. It is nothing short of a revolution in the theory of evolution, and Noble thinks it may go some way to explain speciation. Speciation, according to Neo-Darwinism, occurs through the accumulation of slow, gradual changes in the gene pool of a species. Noble, contrastingly, writes:

> "It is difficult to see how this sort of gradual accumulation of small changes would itself lead to the creation of distinct species, speciation, which is a major feature of evolution. Such minor modifications would simply be absorbed in the population. By contrast, evolution shows explosive periods of new species creation such as occurred in the 'Cambrian explosion', some 500 million years ago. There is now evidence that speciation occurs when significant changes are happening rapidly in the genome."[23]

If one could show cells swapping entire genomes, the Neo-Darwinists would have claimed the genomes have just translocated and have not been altered. If one could prove that cells cannot swap any part of their genomes, the Neo-Darwinists would have claimed they were right and that the genome is immutable except through the processes that concord with their theory. If one shows, as Shapiro has done, that cells manipulate their genes—to varying degrees—without receiving commands from the genes to initiate this, and without random errors being the cause of this, then the Neo-Darwinists should have no leg to stand on, yet they remain stubborn. Any persistence beyond this point is usually motivated by one of three things: ideology, a sunken cost fallacy, or the inability—or unwillingness—to stray from an established orthodoxy. And though such persistence is not a crime in a legal sense, one is reminded of the words of Cornelius Tacitus, "Crime, once exposed, has no refuge except in audacity."[60]

CHAPTER 7

The Weismann Barrier Pillar

In the previous chapter we mentioned that three out of the four pillars of Neo-Darwinism had been proven untrue, and we expounded upon some of the many ways this had been done. Here, our attention turns to the fourth pillar, which we labelled in Chapter 2 as the Weismann barrier pillar. It is the hypothesis that somatic alterations in the structure and function of organisms within a single generation cannot be transmitted through the germ line.

August Weismann, the eponym of this pillar and author of *Das Keimplasma: eine Theorie fer Vererbung*, was an influential late 19th century German biologist best known for inventing the Weismann barrier principle—the belief that the germ cells of an organism are inherently distinct to the somatic cells of the same organism. Weismann thought that only germ cells were capable of transmitting genetic information, meaning that traits acquired through experience or the environment are not inherited. This paved the way for the chromosomal theory of inheritance, in which genes on chromosomes are the only determinants of phenotypes. It is important to note that this is not a nature vs nurture discussion, as even the most committed Neo-Darwinists accept that the environment can affect organisms. What they don't accept, however, is that non-genetic factors influence future generations and that they do so without being 'commanded' to do so by the genes themselves.

It was Weismann's theories that Dawkins leaned heavily on when propagating his selfish gene narrative. Dawkins echoed Weismann in the separation of germ and somatic cells, reinforcing the belief that evolution is driven by genetic information undergoing random mutations that are then passed on to subsequent generations, and rejecting the idea that acquired traits may be passed on. Dawkins alluded to the Weismann barrier in *The*

Selfish Gene, stating that genes were "safe inside gigantic lumbering robots, sealed off from the outside world."[26]

Dawkins' storytelling and polemical discourse is problematic when trying to have a technical discussion, as it moves between metaphor and literal claim, purposely obfuscating the boundary between them. We discussed this earlier in Chapter 4. However, there are times when Dawkins is more explicit in his claims, and this helps our cause greatly, as the claim is unshielded by rhetoric from scrutiny. Dawkins wrote:

> "Genes do indirectly control the manufacture of bodies, and the influence is strictly one way: characteristics acquired after birth are not inherited. No matter how much knowledge and wisdom you acquire during your lifetime, not one jot will be passed on to your children by genetic means. Each new generation starts from scratch. A body is the genes' way of preserving the genes unaltered."[23]

Adhering to this Weismann barrier pillar is one of the ways in which Neo-Darwinists differ from Darwin himself. The latter theorised a pangenetic inheritance pattern that did not differentiate germ cells from somatic cells.[61] Weismann conceived of a germ plasm from which soma proliferated. It was only the germ cells which were thought to be inherited—and, thus, immortal—and the soma was considered to develop afresh from each new generation of germ plasm.[62]

As with the previous three pillars, Noble has taken issue with the Weismann barrier pillar. He argues that not only is this pillar now disproven, but it never had a good evidentiary basis to begin with. In the late 19th century, Weismann developed a now-famous experiment to disprove Lamarkian evolution and the possibility of inheriting acquired traits. The premise was simple—Weismann took a study group of mice and amputated their tails. He allowed the amputee mice to mate with normal mice to show that the offspring would not be born without tails. Thus, he concluded, inherited traits do not pass on to future generations.

Putting aside the rather cruel and unnecessary nature of the study—the child of any amputee human would have sufficed to inform one that children of dismembered parents are not born limbless—one can see why Noble thought that such studies were poor grounds on which to base such a far-reaching theory. Noble argued that the experiment was conceptually flawed as it tested a trait that did not confer a survival benefit—there is no real advantage to a mouse being tail-less, and so a trait such as that would not be selectively pressured by the environment into being passed

on. Nevertheless, this experiment has been taught to generations upon generations of schoolchildren as evidence of Neo-Darwinism.

The rise in epigenetics has led to much scrutiny of the Weismann barrier. Epigenetic changes have been shown to affect phenotypes, and these changes have been shown to pass on to future generations without a need to change genes. This completely throws out all four of the pillars of Neo-Darwinism that we discussed, including the Weismann barrier pillar. These epigenetic changes are also faster than genetic changes, and can thus respond quicker to challenges—they are not insignificant and cannot be ignored. Medically, this means that is a person's parent makes poor lifestyle choices, it can have a knock-on effect on their children, something that physicians have long intuited. Somatic changes are transferrable.

Noble explains what years of research in epigenetics has led to:

> "In summary, it is clear that the paternal lineage is responsible for far more than just its genetically-encoded information. A variety of distinct epigenetic mechanisms, such as DNA methylation, histone modification and small RNAs, may collectively reflect prior and current environmentally-determined phenotypes in the father, thus providing a robust legacy of critical molecular information for his descendants which contribute to paternally mediated inheritance of phenotypes and initiation of a vicious cycle of disease risk across generations."[23]

Neo-Darwinists question the importance of these epigenetic changes, arguing that they fade away after a few generations and are not inherited within the genome itself. Let us tackle both of these claims. As for the claim that the changes are transient, it has been demonstrated that epigenetic changes can persist for much more than just a few generations, with sustained changes in organism phenotype throughout this period.[63] One example of a study demonstrating this principle was conducted at Emory University and it showed that male mice, when subjected to a particular odour that was paired with a mild shock, developed a profound aversion to that smell. More striking is the fact that their offspring displayed a similar fear to that same smell, despite never having encountered it themselves.[64]

Research focused on human populations that live at high altitudes, such as the Andean and Tibetan populations, has also shown potent epigenetic adaptations. These high-altitude populations exhibit specific DNA methylation patterns that correlate with an enhanced ability to cope with lower atmospheric oxygen levels. These changes are persistent within the populations and offer a clear survival benefit.[65] None of this is dependent

on changes in genome, and so it is obvious why the Neo-Darwinists wish to ignore or downplay it.

The case is similar with metabolic disorders, in which epigenetic changes that affect metabolic pathways have been shown to be hereditary, putting children at risk due to the lifestyle choices of their parents in a way that does not depend on the genome.[66] The examples go on and on, in both the plant and animal kingdoms, but we can stop there for now. The genome, in these instances, appears to be less of a dictating overlord and more of a passive set of code that can be taken or left for the benefit of the organism.

As for the second claim of the Neo-Darwinists, namely, that these epigenetic changes are insignificant as they do not affect the genome, then this is clearly circular reasoning, as it is the genome's importance we are questioning, so arguing that something is not important because it does not affect the genome fallaciously presupposes the genomes centrality.

Noble takes these ideas of transgenerational epigenetic inheritance—which is gaining substantial support from its evidentiary basis—far further than Neo-Darwinists are comfortable with.[67] He explains that rapid speciation is not explainable through standard models of natural selection, and he stressed that epigenetic changes are pivotal in evolution. Noble said, "That's the extraordinary thing, natural selection is not the origin of speciation, it's epigenetics followed by the genetic changes. The epigenetics leads, and therefore, the environment leads."[68] Noble is not rejecting natural selection, he is rejecting the idea that the genome is a dictatorial book of life.

Epigenetics is not the only phenomenon that disproves the Weismann barrier pillar of Neo-Darwinism. Horizontal gene transfer (HGT) similarly should not be possible were this pillar true, yet it clearly occurs. HGT is the process we briefly discussed earlier, through which organisms pass on genetical material to other organisms via transformation, transduction, or conjugation. We used the example of bacteria responding to antibodies earlier to explain how the process occurs. It is very clear that this example, and all those like it, go against the Neo-Darwinist idea of vertical inheritance and dictatorial genes. All of this must complicate our understanding of evolution. If one does not appreciate this then one has not really understood HGT and its implications.

For these reasons, Noble argues that there is substantial evidence to show that the assumptions of gene-centrism Neo-Darwinists have inherited from their predecessors have been falsified:

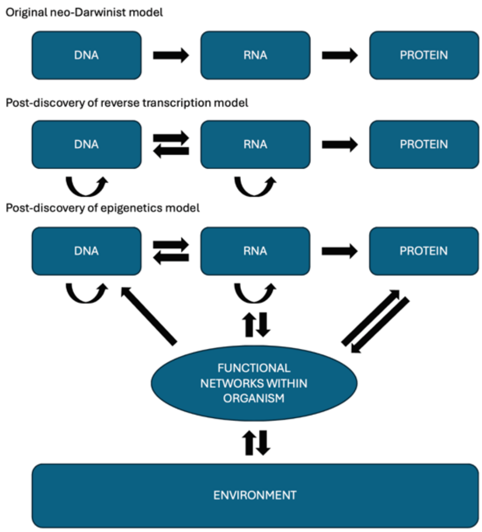
"The gene-centred dogma derives from at least five erroneous assumptions: the concept of the gene as a precise self-replicator; the view of the organism as simply a vehicle to transfer genes with no agency; that natural selection is a passive process in which organisms have no active part; that

changes in the organism cannot be transferred across generations; that DNA is a code or blueprint instructing the organism in its function and behaviour. None of these contentions is true."[23]

CHAPTER 8

The Return of Lamarck

Before we begin the primary discussion on the return of Lamarck, let us study the diagram below. It demonstrates the development of understanding from an early Neo-Darwinist model that was espoused in 1958, to a much more complex and multifaceted model we currently work with. Looking at the early model, one can appreciate why Neo-Darwinists felt that DNA was the origin and command centre for all organic functions. In that linear and rigid paradigm, such a claim made sense. However, this is no longer the case, and such simplistic beliefs are no longer tenable. Following the discovery of reverse transcription, we understood that DNA can undergo modifications independently of RNA, and that RNA can function as a template for analogous processes—these are symbolised by the curved arrows beneath DNA and RNA respectively. Following the discovery of epigenetics—and a rudimentary understanding of the extent of its implications—the diagram opened up even further, with us beginning to appreciate that functional networks within the organism interacted with the world around them and used these stimuli to effect change that could be inherited. So significant is this influence, that it is thought by many to have been the primary impulse for speciation throughout the history of the natural world.



With this context in mind, let us proceed to a discussion on Jean-Baptiste Lamarck. We mentioned him earlier in Chapter 2, where we provided a brief history of the theory of evolution. We mentioned that Lamarck was the first person to provide a naturalist account of evolution that entered public discourse. His theory centred around the inheritance of acquired traits, whereas Darwin, who followed him, proposed a theory that centred around natural selection. We mentioned that, by now, Lamarck had been largely discredited and Darwin's theory accepted as true. For his part, Darwin had begun to accept a number of Lamarck's arguments in his later years, something he made known in the later editions of his book, *On the Origin of Species*.[69]

During their debate, Noble hinted at this fact and Dawkins accepted that Darwin had started to become Lamarckian in some of his later positions, though this acknowledgement appeared to make Dawkins tense. If Neo-Darwinism functions like a religion, then Darwin functions like their prophet, and whilst his followers can admit to his humanity and fallibility, doing so causes them great anguish. And like so many world religions, the uncomfortable truth that the beliefs of the adherents do not concord with those of their leader—either due to ignorant misunderstandings or ideological misrepresentations.

During their debate, Noble analogised the nucleotide of a cell with his fist. He said that if the nucleotide was as large as his fist, then the cell membrane would be as far away as Scotland, yet signals are still passed from the cell surface to the nucleus.[68] Calcium ions entering through protein channels in the membrane trigger a chemical reaction that produces a messenger

molecule that attaches to tubulin molecules within the cell. These tubulin molecules behave like train tracks and transport the messengers to the nucleus, where gene expression can be altered.

Noble stressed the frequency with which these processes occur. The cell amazingly signals to its proofreading system to downgrade error-correction mechanisms, promoting faster changes in the genome and, thus, faster responses to the environment. Millions of new DNA sequences arise from these processes, and the organism can then utilise the sequence which confers the best survival benefit. These chosen sequences make their way to the germline. Neo-Darwinism's lack of acknowledgement of these methods reflects a large black hole in their theory.

Referencing the work of Zhang et al—who demonstrated the intergenerational transmission of paternally acquired metabolic disorders though non-coding RNAs—Noble arrives at a remarkable conclusion:

> "… a small non-coding RNA that's a little bit of technology but a new sequence generated by the organism can pass to the germline cells which become eventually, of course, the eggs and the sperm, and what that will do is then tell the next generation to inherit the metabolic characteristics that were conveyed by that. I'm sorry to say this, because I know this is a dirty word amongst most evolutionary biologists, but Lamarck is back—very simple."[68,70]

Dawkins' response to this challenge is particularly telling of how he does not address the challenge at hand but evades it and conveniently shifts position:

> "Well, if Lamarck is back in an indefinite number of generations, I'm impressed. If it's only for a couple of generations, I'm not… But let's suppose that it is for a larger number of generations. If that's true, then I would have to revise what I say to include any change in the germline [which] then now becomes admitted into the charming circle of replicators, and that's fine. I doubt it but I don't want to be dogmatic about saying that the DNA in the existing germline is all there ever was. If on some other planet, and maybe on this planet, it's true, the germline can be altered, then that's fine, the broad church of the selfish gene can embrace that. As I say, I doubt it."[12]

When we look closely at this response, it becomes immediately evident that Dawkins does not deny the non-Neo-Darwinist processes we mentioned earlier. Rather, as we discussed earlier, he wishes to downplay their significance. Nevertheless, Dawkins is reluctantly willing to accept that these

processes may be very significant both in their effects and in their long-term impacts. However, if this is so, Dawkins wishes to include whatever is involved in this process as a 'replicator'. The contradiction is startling.

Recall Chapter 4, in which we explained the problem with using loose language in technical discussions. This is a prime example of that problem. We had quoted Dawkins as saying, "… that was no metaphor. I believe it is the literal truth", when he was pressed on his selfish gene theory.[36] Yet here we see him completely abandon any literal definition of gene to try and not lose an argument. No biologist in their right mind would count organelles and non-DNA, sub-organelle structures as 'genes'. It would be completely untrue to claim as much, and Dawkins should know this. If he was honest and direct, he would need to admit that his conceding the existence and persistence of such processes is akin to him conceding defeat and the falsification of his theory. In an objective world, this would not be an issue, but since Dawkins' evolutionary views are tied intimately with his philosophical positions, such a concession is never countenanced.

Saying that your church is wide enough to accept newcomers is meaningless at a technical level, and whilst the faithful may well be pacified with such a claim, the experts, such as Noble, are understandably frustrated by it. Dawkins never addressed the obvious clash and refused to engage with it technically. Noble voiced his annoyance with this after the interview and referred to Dawkins' polemics as unhelpful to actually resolving the issue. Had Dawkins accepted that the central dogma of selfish gene theory would be in peril if Noble's arguments were valid, then a more granular discussion would have been possible.

Regarding the temporality of epigenetic changes, Noble mentions that epigenetic changes can even lead to genotype changes as the former are used to test the waters, so-to-speak, and 'decide' which mutations are beneficial. When a survival benefit is identified, then the following generations have the opportunity to keep or lose the changes. It is beneficial to the organism that not every change becomes permanent, because environmental challenges fluctuate in intensity and change in type, meaning that what is beneficial for one generation may not be beneficial for the next. If, on the other hand, a permanent change is considered beneficial to an organism, then the organism may 'choose' to assimilate the change into its genome.

To evidence the possibility of this last claim, Noble cited the work of Conrad Waddington, a British geneticist and evolutionary biologist from the 20th century. Waddingtom performed some rather elegant experiments with fruit flies. Waddington used subtle environmental stimuli (e.g. heat) to induce somatic changes in fruit flies, and he discovered that it took about 14 generations, on average, for the response to a sustained stimulus

to be assimilated into a genome—in evolutionary terms, this is considered incredibly rapid.[71] This is an example of something external to the genome causing permanent change in an organism through external influence, with no decision-making from the genome being involved. The rapidity of it also suggests that far more than the cantankerous natural selection of Neo-Darwinism was taking place.

During the debate, Dawkins never addressed the central question of how epigenetic changes—induced through external means—leading to permanent changes in the genome of an organism fits within a Neo-Darwinist framework. Nor did he address how it fits into the idea of an active, causal, selfish gene. Instead, he took the conversation into another direction; he argued that the changes were not Lamarckian but actually Darwinian. This led to a peculiar exchange in which Noble agreed with Dawkins but insisted that the changes were Darwinian only insofar as Darwin was Lamarckian. Dawkins conceded that Darwin did become somewhat Lamarckian in his later life, but that he felt the biological point being made was still insignificant. It would help, of course, if instead of just calling it insignificant, he actually addressed its premises and conclusions directly.

Regarding Darwin himself, Noble felt his Lamarckism was not a passing fancy but a significant part of his later thought. Recalling how Darwin worked with Noble's own predecessor, Burton Sanderson, and his student George Romanes, Noble pointed out that Darwin took Lamarckism seriously enough to invent a theory of gemmules.[12] Lamarck's concept of use and disuse affecting genomes was known to Darwin, and the latter seemed to think there was some truth in this without knowing how it would work. Regarding this, Noble said:

> "Otherwise, as you beautifully expressed earlier, all that information would be lost. So how could that be communicated? He couldn't identify a mechanism, so he proposed that tiny particles released by cells, which he called gemmules, might pass through the bloodstream to the germline. He admitted it was just a hypothesis at that time—he couldn't see them with the microscopy available then."[12]

With modern microscopy, however, we have been able to identify extracellular vesicles which communicate directly between the soma and the genome. They carry genetic material and affect change based on environmental pressures. Darwin may well, as Noble suggested, have hailed this modern discovery as one that validates his pre-modern, Lamarckian hypothesis.

However, even if we accept that to be true, it does not answer Dawkins' question on temporality and permanence. We may know the mechanisms underlying these processes, and we may even be able to clearly show how non-genetic factors can be inherited and affect species on population-wide levels, but how many generations would this change need to be sustained for before it would be considered meaningful for Neo-Darwinists? Dawkins was asked this question directly, and he did give a definite answer. The only thing that would change his mind is if these changes we discussed were noted in the genome directly.[12]

We mentioned earlier how this reasoning is jarringly circular. It presupposes the centrality of the genome and then declares all else to be insignificant unless it alters the genome—all this to make the claim that the genome is central (which was the presupposition). That is, of course, unless Dawkins wishes to give up on the selfish gene idea and afford agency and control outside the genome. One cannot both have their polemical cake and eat it.

For his part, Noble agreed that it would be necessary to examine the effects of these changes over a long period of time to see how significant they were in evolutionary terms. He argued that we have done so, and have evidence of these effects over billions of years, referencing the findings of the Human Genome Project that were published in a 2001 paper in Nature.[32] Figure 42 of this paper shows how genomes had undergone significant alterations by rearranging large segments—a process Shapiro refers to as genome reorganisation and natural genetic engineering.[32] This was clear evidence of changes occurring and persisting over evolutionary timescales, but Dawkins offered no response to it.

Like this, the debate between the two Englishmen ended. Noble expressed his frustration with Dawkins afterwards, saying that the latter would avoid directly tackling issues and would, instead, discuss tangential matters as a distraction technique. Noble felt that Dawkins was unaware of much of contemporary molecular biology and this hindered his ability to grasp concepts more fully.

Despite whatever excuses one makes for Dawkins, the outcome of the debate was a clear victory for Noble, but that is not the important thing. What is more important is that people open their minds and learn from what took place. If Neo-Darwinism becomes untenable, it should not lead to sadness but to optimism for new theories to emerge and better explain our world. This should excite the inquisitive mind and motivate the slumbering scientist. Let's keep progressing and see what is out there to be discovered.

"The aim of argument, or of discussion, should not be victory, but progress."[72]

CHAPTER 9

Reductionism vs Holism

There was more at play during the discussion between Dawkins and Noble than simple biology. Behind the cordiality and sobriety of the panel setting were ideological points being defended tooth and nail. It is difficult to know Noble's philosophy, as he has not made a career out of espousing it, nor has he written at any great length about it, but it is not lost on us that he also has a philosophical paradigm he wishes to defend.

With Dawkins, the matter is much simpler. He prefers any and every form of reductionism afforded him, as this limits, in his mind, any space for theology and metaphysics. To Dawkins, a purely physicalist, determinist, and inorganic world without free will, love, objective aesthetic, and consciousness is a world in which there can be no heaven, no hell, and no God. So the more he can argue for a reductionist worldview to be the case, the stronger he feels his other arguments become. Conversely, if holes in the extreme reductionist theory begin to appear, then the church of New Atheism built upon those foundations begins to crumble.

With all this at stake, there is no wonder why the debate felt less like two scientists trying to work through a problem and more like two individuals fighting for their team to win. In truth, the polemicism was not uniform, as it did seem that Noble primarily came to debate science and Dawkins primarily came to protect an ideology. This led to some frustration during and after the debate, and it even led to Dawkins wishing for the meeting to be called a discussion rather than a debate. A poor showing at a debate is more injurious to the faith of one's followers than a lacklustre discussion.

In biological terms, reductionism posits that complex biological and behavioural phenomena can be understood by dissecting them into simpler, purely biological components. This perspective aligns with a mechanistic view of biology, where organisms are seen as complex machines whose

functions can be fully grasped by analysing their individual parts. Dawkins forwards this reductionism in his influential writings and argues that genes are the fundamental unit of natural selection, serving as the primary agents in the evolutionary process.

Extending this biological reductionism further into psychosocial reductionism, Dawkins asserts that all human behaviours can be traced back to evolutionary imperatives encoded within our genetic makeup. For example, he discusses concepts such as kin selection and reciprocal altruism to elucidate psychosocial behaviours, framing even altruism as an evolutionary strategy that ultimately benefits gene propagation. This deterministic outlook implies that our deeply biological and selfish predispositions govern our actions and interactions, prompting philosophical inquiries into free will, ethics, and human agency.

Noble believes that Dawkins does not understand the deeper implications of his own stance:

> "I would sometime say that Richard's position is very much like a religious position. It's got the following characteristics: it's dogmatic—it cannot consider that you might be wrong; second, it's got the fantastic notion of original sin—we are born selfish. My goodness me! Does he understand what he is saying when he says that?"[73]

To Noble, behaviour can never be entirely understood through a reductionist lens that discounts higher principles and focuses only on genes. Dawkins' reductionist view not only determines us as being categorically selfish but it would even undermine free will. Human behaviour is shaped by a complex interplay of genetic, environmental, and contextual factors, as well as individual agency, underscoring the need for a more integrative approach to studying biology. To not strawman Noble's idea, one must appreciate that he never rejects genetic factors, he just does not feel they make a complete 'book of life'. Rather than being inherently selfish or cooperative, Noble suggests that individuals possess free will, enabling them to make choices that have outcomes.

Dawkins' view compels him to moral relativism and determinism, both of which are at complete odds to his own moralising and polemical behaviour. This juxtaposition highlights how incompatible such worldviews are with our reality. We intuit that we have agency before we even intuit the logic required to make a syllogistic argument. If our agency is in question, then so, too, is the syllogism with which we question it, and if that is what one thinks, then they have reached pyrrhonian skepticism. This extreme

skepticism is also unfounded, as the argument for it is circular. How can an argument that rejects logic ever be logical? It is a paradox. To the blindly faithful, no amount of debate will dissuade them from persisting in their beliefs.

A holistic worldview provides a broader lens through which we can study human behaviour. We begin to see our behaviour as being shaped by our experiences, environments, and interactions with others, not just on a superficial and non-causal level, but on a deep and causal one. Humans are seen as vitalistic organisms with real moral choices to make. If one kills a child, the excuse of, 'This was predetermined millennia ago by the genes I was to inherit' would never be tolerated, and so it should never be accepted, because human free will is appreciated by most people as more than just an illusion—it is a reality we are obligated to contend with.

This holism is appreciated only if we appreciate the function and interplay of each level of the organism, from the genes to the tissues to the organs to the organism itself. Noble's research in biological systems illustrates that emergent properties arise from the interactions between these levels, leading to complex behaviours that cannot be predicted through genetic information alone.

Advancements in epigenetics and molecular biology have strengthened Noble's arguments to the chagrin of Neo-Darwinists. We now understand how factors external to the genome can influence gene expression without altering the underlying DNA sequence. We also understand how these processes can lead to the eventual alteration of the code itself. Both of these facts completely overturn the reductionist framework of Neo-Darwinists.

The philosophical contention between reductionism and holism is not new. The former viewpoint is largely associated with people seeking objective worldviews and complete knowledge through the dissection of complex systems into simpler parts. The latter emphasises the limitations of this approach, and of human enquiry in general, arguing that higher-level properties cannot be entirely explained by studying their lower-level components. Holistic thinkers tend to think the reductionist ones are cognitively dissonant in their practice and overly restrictive in their theory. Nils Roll-Hansen, a philosopher and historian of biology, observed, "There is a widespread feeling among biologists that the Modern Synthesis (Neo-Darwinism) of the mid-twentieth century led biology into a 'reductionist' paradigm that needs to be broken for new progress to be made."[74]

Further, despite the polemical back and forth, there remains quite a large elephant in the philosophical room that was never addressed by Noble or Dawkins. Academics are thought to be neutral and have no biases leaning them one way or another. It is my opinion that this feigned neutrality is un-

helpful. In the words of Alasdair McIntyre, "The neutrality of the academic is itself a fiction of the encyclopaedist, and I reveal my antiencyclopaedic partisanship by calling it a fiction."[14]

The elephant not being addressed in this case is that of theology and metaphysics. Are either theology or metaphysics possible alongside Dawkins-esque reductionism? The simple answer to this is yes, and it begs the question as to why Dawkins does not see that it. Identifying how the world works in an increasingly granular fashion does not explain the question of why there is something as opposed to nothing? Nor does it explain any of the major philosophical questions posed throughout the eras. To think it does is to do three things: [1] commit a category error, assuming that searching for more and more detail must answer a question that is posed elsewhere; [2] erroneously assume that linguistic reinterpretations of mechanical actions in any way answers longstanding philosophical questions of causality; and [3] falsely argue that anything which is non-physical is non-existent—an unprovable hope of many philosophical reductionists.

A more detailed exposition of the philosophies underlying both camps of biologists is beyond the scope of this book. For now, suffice it to say that when Dawkins lost the debate, he lost far more than just a debate over science. It is for that reason that both he and his followers would prefer that it not be called a debate, and it is for that reason why many of Dawkins' answers during the discussion were coy and indirect. Giving direct and open answers leaves one vulnerable to a response—perish the thought! Neo-Darwinism may be dead, but it did not die alone. Along with it died a philosophical movement that was dear to many.

CHAPTER 10

Noble's Ten Principles

"The king is dead! Long live the king!" proclaimed the masses upon the death of King Charles VI and the accession of his son, King Charles VII. This epanadiploic phrase alludes to the inevitable arrow of time and the continuation of the status quo. And whilst it may feel like nothing will change no matter how many debates are had and theories are put forward, this is not quite accurate. Kingships are replaced by democracies, republics, and theocracies. Similarly, scientific revolutions seem impossible until they are shown to be possible.

The unorthodox central theories espoused within this book and elsewhere are nothing short of revolutionary if they are understood properly and taken up. But a revolution without an aim is pure anarchy, and to destroy but not to rebuild is to oppress. If we are sincere in our search for knowledge and in our scientific endeavours, then we should be looking to build new paradigms to replace the dying ones. Just like Newton's physics replaced Cartesian reductionism those many years ago, so, too, must we replace the reductionism of today with theories of our own, theories that are in line with the data we now have available to us.

On 18 December 2007, Denis Noble published an article in *Experimental Physiology* titled, *Claude Bernard, the first systems biologist, and the future of physiology*.[76] Bernard, the protagonist of the early portion of Noble's essay, was a 19th century French physiologist who was perhaps the first person to respond to reductionism with a systems-based biology that accounted for non-material factors. He was the first to formulate a concept of homeostasis—*milieu intérieur* in French—and he was described as "one of the greatest of all men of science" by Bernard Cohen from Harvard University.[77] Bernard had the following to say of chemical reductionism:

> "Organic individual compounds, though well-defined in their properties, are still not active elements in physiological phenomena. They are only passive elements in the organism... The living organism does not really exist in the *milieu extérieur* but in the liquid *milieu intérieur*… a complex organism should be looked upon as an assemblage of simple organisms… that live in the liquid *milieu intérieur*."[77]

One must be careful not to exaggerate and represent Bernard as a traditional mysterianist. If anything, he aimed to be a synthesiser who found physico-chemical explanations for metaphysical phenomena without reducing these phenomena to illusions. Much work has been done since Bernard's time in the field of molecular genetics, and our challenges today are somewhat different to those he faced. Noble wrote the following:

> "The problem physiology faces today both resembles that faced by Bernard and differs from it. We face a new form of reductionism: that of genetic determinism, exemplified by the idea that there is a genetic program, what Jacob and Monod called 'le programme génétique'. This challenge strongly resembles that of 'reducing life to physics and chemistry', the chemical being DNA. The major difference from Bernard's day is that we now have more facts than we can handle. There is a data explosion at all levels of biology. The situation is almost the reverse of that in Bernard's time. I have no doubt, therefore, that if he were alive today he would be championing his 'application of mathematics to natural phenomena.' I will illustrate why this is necessary and how it can be achieved by outlining some principles of systems biology from a physiologist's viewpoint. The principles are derived from my book on systems biology, *The Music of Life*, but their arrangement as a set of 10 was first presented by Noble (2007)."[76]

We will outline and briefly expand upon these principles of Noble below, though a comprehensive discussion is not our aim here. For a more fleshed out rendering, refer to the work of Denis Noble, especially his book *The Music of Life* and his 2007 article in *Experimental Physiology* that we referenced earlier. Much of this chapter is taken directly from that 2007 article.

Principle 1: biological functionality is multilevel

This first principle is both true and uncontroversially accepted by all biologists, making a good starting point. Biological functionality is clearly

demonstrated at more than just a genetic level. There is obviously more going on, however which way one wishes to explain those goings on. However, Noble contends that the language of modern reductionist biologists tends to obfuscate this evident truth. Without directly calling it untrue, they speak of genes using metaphors such as the 'book of life', as if those genes are the only active participants within an organism. Noble writes that, "In its strongest form, this view of life leads to gene-selectionism and to gene-determinism: 'They [genes] created us body and mind.'"[76] According to Noble, even Dawkins does not really believe this last statement of his, and the latter seems to qualify this remark of his throughout his works with enough qualifications to render it meaningless.

From the perspective of the organism, DNA molecules are seen as captive databases that may be used to replicate onwards, or be disposed of if the organism decides not to propagate. In isolation, these genes are non-functional strands that would simply die out. All the functional processes within the body cooperate to achieve a desired outcome. Maynard Smith and Eörs Szathmáry—both quoted by Noble in his 2007 article—expressed it thus, "Co-ordinated replication prevents competition between genes within a compartment, and forces co-operation on them. They are all in the same boat."[78]

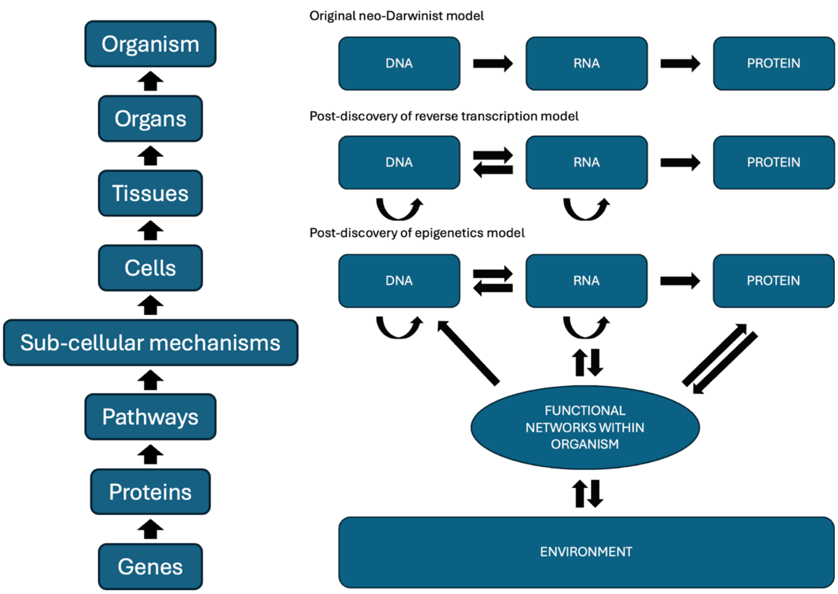
Principle 2: the transmission of information is not one way

This principle was discussed at some length throughout this book. Essentially, the principle is the opposite of the central dogma of Neo-Darwinism, which states that organisms are incapable of changing their own genetic makeup, making causation unilateral and not allowing for the possibility of the environment to affect genes. The multi-directional transfer of information means that genes not only 'command' but are 'commanded'. Uni-directional causation would support a selfish gene theory and it would protect Neo-Darwinists from Lamarckian challenges. This is why we mentioned the return of Lamarck after showing how the central dogma of Neo-Darwinism was disproven.

Noble argues that the central dogma is at the very least incomplete as it defines information only in terms of nucleotide sequences, and whilst we know that nucleotide sequences can inform us which proteins can be made, we also know they do not inform us how much of each protein will be made or when they will be made or why they will be made or with what else they will be made. 'How much?' is among the most important question of any living cell, and differences in quantity affect both function and survival. Noble points out multiple examples to stress this point,

including the speed of conduction in nerve cells being dependent on the density of sodium ion transporters (proteins) available, as well as his own work on cardiac electrophysiology, which showed that ionic currents within myocardium were so finely balanced that it was "inconceivable that nature arrives at the correct expression and activity levels without some kind of feedback control."[76]

Noble argues that feedback control of gene expression is not a new or controversial concept, yet it remains critically important to the cell. These feedback loops are equally important as the raw DNA sequences in terms of differentiation and growth, and it cannot be denied that the information is transferred both from the DNA and to the DNA. The diagram below is a reminder of the development of our understanding of information transfer in biological systems. The original Neo-Darwinist model—founded in the 1950s and propagated since then—is displayed at the top on the right-hand side, as well as on the left-hand side in more detail. This linear and restrictive model permitted only the one-way transfer of causality, ignoring all information transfer in other directions and between other components of the organism, deeming them subservient to the arrow from DNA to RNA.



Noble takes great issue with this, writing lucidly:

> "The genes are told by the cells and tissues what to do, how frequently they should be transcribed and when to stop. There is

'downward causation' from those higher levels that determines how the genome is played in each cell. Moreover, the possible number of combinations that could arise from so many gene components is so large that there wouldn't be enough material in the whole universe for nature to have tried more than a small fraction of the possible combinations even over the billions of years of evolution."[76]

Thus, the central dogma of Neo-Darwinism is incomplete, but Noble goes further to say it is also irredeemably incorrect in several ways. For example, whilst protein sequences are not back-translated into DNA, there is growing evidence to show that the environment does alter the genome through mechanisms such as gene transfer. Further, epigenetics has shown that DNA is marked by the organism (e.g. via methylation of cytosine and interacting with histone molecule tails) in a manner that modulates gene expression and repression. Noble stresses that whether we consider this marking and modification an alteration of the gene code or not is a linguistic distinction and not a biologically important one in terms of outcome for the organism being studied, especially when we know these modifications can persist for extremely long periods of time. The fact that they can be reversed is irrelevant, as a change in DNA sequence can also be reversed.

Principle 3: DNA is not the sole transmitter of inheritance

Most Neo-Darwinists would agree with the first two principles. The facts are now far too apparent for them not to agree. However, they would argue that the logical entailments of the principles are other that what I stated. This is not helped by the very vague definitions of 'gene' we come across in the works of Dawkins and others. If a gene is 'anything that replicates' then you have definitionally excluded non-replicators and so an argument such as, 'therefore, only genes are inherited' is circular.

Noble writes:

"Genes, as originally conceived, are not just the same as stretches of DNA unless we subscribe to the view that the inheritance of all such characteristics is attributable entirely to DNA sequences. That is clearly false, since the egg cell is also inherited, together with any epigenetic characteristics transmitted by sperm, perhaps via RNA in addition to its DNA, and all the epigenetic influences of the mother and environment. Of course, the latter (environment) begins to be about 'nurture' rather than 'nature', but one of my points is that this distinction is fuzzy. The proteins that

> initiate gene transcription in the egg cell and impose an expression pattern on the genome are initially from the mother, and other such influences continue throughout development in the womb. Where we draw the line between nature and nurture is not at all obvious. There is an almost seamless transition from one to the other. 'Lamarckism', the inheritance of acquired characteristics, lurks in this fuzzy crack to a degree yet to be defined"[76]

Many who are not well-versed in molecular genetics are forgiven for not realising that the egg cell is also inherited in a number of ways. It provides the cellular machinery to allow DNA to be read, as well as the cellular structures which facilitate this. Most of this, Noble points out, is not coded for by DNA but is essential for cell function and replication. He even questions whether the exclusion of epigenetic inheritance from the germ cell line is necessary for multicellaular harmony, given that specific eggs are needed for specific sperm cells.[76]

Considering how many different cell types there are in the body—the current estimate sits at around ~200 different types—and considering that all these cells arise from germ cells, one can begin to appreciate some of the advantages of epigenetic gene marking. Having undifferentiated cells marked before selectively differentiating and adapting them is far more useful and less unwieldy than having changes baked into the DNA sequence itself, where its effect would be more widespread and less controllable. The selectivity afforded by resetting the germ-line inheritance means that certain cell types can benefit from gene marking to the exclusion of other cell types which would have been harmed by the same markings were they to have been non-selective.

Either way, one should have no qualms with accepting that DNA is not the sole transmitter of inheritance. This statement is a simple and provable one with the examples given earlier in this book, as well as the epigenetics discussed here. One can become confused if they equate DNA coding with inheritance to the exclusion of all else. Noble highlights that whilst metaphors like "code" are useful to describe DNA, one must not get carried away and lose the wood for the trees. Claiming that only that which is 'coded' (i.e. represented as a string of information that can be 'read') is inherited is to arbitrarily ignore other forms of inheritance. Other things that are inherited may not need to be coded in the first place. After all, what is code other than data that can be interpreted?

Noble writes:

> "The rest of cellular inheritance is not so coded; in fact, it is not even digital. The reason is very simple. The rest of the cellular machinery doesn't need to 'code for' or get 'translated into' anything else for the simple reason that it 'represents' itself; cells divide to form more cells, to form more cells, and so on. In this sense, germ-line cells are just as 'immortal' as DNA but a lot of this information is transmitted directly without having to be encoded. We should beware of thinking that only digitally 'coded' information is what matters in genetic inheritance."[76]

Principle 4: the theory of biological relativity—there is no privileged level of causality.

Noble begins his fourth principle with a maxim that outright rejects causal reductionism, "A fundamental property of systems involving multiple levels between which there are feedback control mechanisms is that there is no privileged level of causality."[76] There is a longstanding philosophical debate on the nature of causality and relationships that was never going to be resolved in a quick debate between two biologists. This is partly why there was an impasse between Noble and Dawkins during their meeting.

A large degree of the clash between those debating causality is due to the abstract nature of the word itself and the ineffable nature of the world we inhabit. If a cause is defined as an action which leads to another and precedes it in time, as the word is normally used, then there should be no discussion over this fourth principle. Very clearly, the primary outcomes of an organism are preceded by events at all hierarchical levels of the organism. Whether one wishes to accept it or not, we do have the capacity to think and to decide, and we do not need to wait for genetic instructions before doing so. Our organelles also function without instructions from genes. Ditto for our cells, tissues, and organs. And we already discussed some essential components to our survival, such as what lives within the egg cells, that are not found in our genomes nor take instruction from it. All of this and more is a form of causality.

Limiting causality arbitrarily to a sequence of nucleotides is absurd. To attribute such limited causality would need evidence beyond mere metaphor and storytelling. Primacy is not an argument as inorganic matter preceded DNA, and chronology is not an argument as lifecycles are cyclical, meaning we would need to attribute causality at every step within the cyclical chain. Furthermore, any limiting of causality to DNA does not account for the emergence of new features for which individual components cannot take

sole credit—the whole being both greater and entirely different to the sum of an organism's parts.

This latter phenomenon is not unique to the biological world and so the maxim is found elsewhere:

> "Complex systems are systems of many interconnected components that collectively exhibit emergent features, which cannot, in practice, be derived from a reductive analysis of the system in terms of its isolated components."[79]

> "… downward causation is efficient cause that is informed by information embodied at the higher level of pattern."[80]

> "The whole is to some degree constrained by the parts (upward causation), but at the same time the parts are to some degree constrained by the whole (downward causation)."[81]

And what makes this principle even more watertight is that any claim to the opposite bears the burden of proof. One may assume that either we don't know what is causal, or they may attribute causality to all levels that 'act', but to limit it to a single level without proof is unfounded. The proponents of a selfish gene model have not sufficiently overcome the challenges posed by a systems-based model with emergent properties outwith the realm of lower-order components, and until they do, their theory remains nothing but wishful thinking.

Principle 5: gene ontology will fail without higher-level insight

We wrote earlier about the problems in defining 'gene', and it is important to stress that these problems are not trivial. Molecular geneticists define 'gene' as a stretch of DNA that codes for proteins. It is not linked to any higher function, representing a change from the original understanding of gene, which was to do with components that were responsible for higher-level phenotypes. A protein is not a phenotype, and no single gene represents a phenotype in a clear and non-dependent way. Each time we attribute functionality or pathology to a gene, we do so for convenience but not to be technically accurate. Noble provides multiple examples of genes named after functions or phenotypes that are, when studying them at a technical level, not independently responsible for those functions and phenotypes.[76]

Biological function arises from the interactions between cells, and it includes the work of proteins, lipids, and all else. Thus, to attribute causality to organic molecules for higher-level functions without the molecules even

being able to dictate function or phenotype without external support is unwise. This external support is also blind towards the higher-level functions and phenotypes. Only when considered collectively do the pieces fit into place and an idea of control comes about. The function of a gene is related to the protein it makes—that is all the gene can ever do. The gene 'knows' nothing else—higher-level functioning is an emergent property of the system and not inherent within any gene.

Those well-versed in molecular biology are aware of the lack of higher functions in gene sequences. They are aware that every example anyone tries to find in opposition to this principle is eventually disproven. It is for this reason, Noble declares, that the Gene Ontology (GO) Consortium wrote, "oncogenesis [cancer production by a gene] is not a valid GO term because causing cancer is not the normal function of a gene."[76] Going further, Noble writes:

> "Thus, GO assigns three categories to a gene, namely molecular function, biological process and cellular component, which are not intended to deal with higher-level function. It specifically excludes protein domains or structural features, protein–protein interactions, anatomical or histological features above the level of cellular components, including cell types, and it excludes the environment, evolution and expression. In other words, it excludes virtually all of what we classically understand by physiology and most aspects of evolutionary biology."[76]

Therefore, if we wish to involve genes in our discussions on causality and thought, we must appreciate that discussing genes alone will not suffice. Higher-level insight is needed if one wishes for higher order principles to condescend to the level of the genome.

Principle 6: there is no genetic program

Jacques Monod, André Lwoff, and François Jacob were 20th century physiologists who won a joint Nobel prize in 1965 "for their discoveries concerning genetic control of enzyme and virus synthesis" after having worked together for years in the research department of the Pasteur Institute.[82] Monod and Jacob in particular are credited with introducing the idea of a genetic program to the world. Noble reflects on the point that, in the mid-20th century, computers were fed with punched card or paper tape that contained a sequence of instructions.[76] Perhaps this was the inspiration for Monod and Jacob's rendering of the genetic 'code'.

However, there are major differences between a computer system with a punched card code and an organism with DNA, not least of which is the rather obvious fact that the punched card is external to the machine, unlike the DNA, which is a part of the organism, interacting directly and indirectly with its many levels. Noble states that genes are unlike computer codes for the rather simple fact that the latter codes and the former does not! Genes would be more like a computer database—there are no instructions, only sequences that may or may not be activated. A code has a working algorithm: do X, then if Y, do Z. Genes do not function like this. To identify the remaining parts that are involved in an organism's internal system, we must move far beyond the genome itself.

Recall Noble's work with the circadian rhythm that we discussed earlier. He references this work to expand upon this principle, saying:

"Thus, as we have seen above, the sequence of events that generates circadian rhythm includes the period gene, but it necessarily also includes the protein for which it codes, the cell in which its concentration changes and the nuclear membrane across which it is transported with the correct speed to effect its inhibition of transcription. This is a gene–protein–lipid–cell network, not simply a gene network. The nomenclature matters. Calling it a gene network fuels the misconception of genetic determinism. In the generation of a 24 h rhythm, none of these events in the feedback loop is privileged over any other. Remove any of them, not just the gene, and you no longer have circadian rhythm."[76]

Even the word 'program' is misleading, Noble mentions, as a network such as the one described above for the circadian rhythm is not programming anything. It is its own entity. In other words, it is the circadian rhythm process itself and it does not just code for the circadian rhythm. Ending this section as Noble ended his sixth principle, we shall quote Enrico Coen—winner of the EMBO gold medal, Linnean Medal, Darwin Medal, Croonian Medal & Lecture, and Waddington Medal for his works in biology and genetics—who wrote, "Organisms are not simply manufactured according to a set of instructions. There is no easy way to separate instructions from the process of carrying them out, to distinguish plan from execution."[83]

Principle 7: there are no programs at any other level

If there are no programs at a genetic level, then where exactly are the programs? Noble argues that there are no programs anywhere. Dawkins likes to use metaphorical language to dramatize and heighten the importance of the genetic level. Noble, in *The Music of Life*, did the opposite and used metaphorical language to show that the importance conferred to genes could

easily be conferred elsewhere. However, Noble wishes to make clear the fact that he does not privilege these other levels with having a program for the rest of the levels. He only used such language to disprove his interlocutor.

As with the circadian rhythm network, all bodily networks are interdependent and have causality attributable to multiple levels. Noble writes:

> "The conclusion is simply that there are no such programs at any level. At all levels, the concept of a program is redundant since, as with the circadian rhythm network, the networks of events that might be interpreted as programs are themselves the functions we are seeking to understand. Thus, there is no program for the heart's pacemaker separate from the pacemaker network itself."[76]

None of this discounts the fact that certain 'levels' within a system have so much impact on the remainder of the system that they are undeniably important. However, even this is a subjective matter and what is important to a systems biologist may differ from what is important to a physiologist, which may itself differ from what is important to a geneticist. Who is to say that the level of an entire organism is less important than the level of a tissue or cell, just because the former is made up of the latter. To say so is to not understand systems and emergent properties.

Principle 8: there are no programs in the brain

Noble's eighth principle is a philosophical one that rejects any distinction between body and mind. He quotes Francis Crick as having argued that all thoughts, feelings, and emotions are but a function of nerve cells, and that the most likely source of all this is the claustrum in the brain.[76] Other anatomical locations have also been proposed and this idea of the mind as a product of the body has persisted since Descartes, whose now infamous dualism put the mind and body in two separate realms.

Perhaps unwittingly, Neo-Darwinists return to this mind-body dualism, albeit in metaphor, to portray a body that controls a mind. Again, they make the fatal error of speaking in metaphor and confusing their own ontological distinctions. In truth, there is no theatre of consciousness that can be explicated from the organism itself. Whatever happens in the brain is whatever happens in the organism—the brain is not a separate entity responsible for producing thoughts; it is a part of the organism. Noble powerfully argues:

> "This [the reductionist view] is a variation of the idea that in some sense or other, the mind is just a function of the brain. The

> pancreas secretes insulin, endocrine glands secrete hormones … and the brain 'secretes' consciousness!"[76]

There is also the rather obvious fact that none of these arguments of consciousness being illusory or being external to the body have been proven. It is a case of professional biologists stepping out of their comfort zone and proving themselves to be amateur philosophers. In the domain of philosophy, wherein these Neo Darwinists have ventured, there is typically far less resistance to those three powerful words which so many of us need to learn to use more: "I don't know!"

Principle 9: the self is not an object

If the mind is not an extricable product of the body, then what exactly is the self? Here, we find Neo Darwinists are again dabbling in philosophy, making bold claims with nothing to prove them. There is nothing in the work of Dawkins that proves the self is an object, yet this assumption is ubiquitous in his work. Dawkins—and those like him—fiercely reject any notion of a soul or spirit, as they are physicalists who believe that all that exists needs to be a physical entity. Most of them then extend this thinking to consciousness, the mind, and the self. These non-physical entities are necessarily illusory in their paradigm, and if they are to attribute this illusion to something, they wish to attribute it to a physical organ, or at least some physical tissue within the body.

Noble writes at length on this principle in *The Music of Life*, even though it is a philosophical one. Kudos to Noble for admitting that this point is more philosophical than biological, as most Neo-Darwinists hope to brush past this point. To them, the self needs a physical locus or there is no self in the first place. Their claim is unproven and unfounded, so either agnosticism in wait of evidence or an alternative view must be considered. Using the systems biology approach, Noble writes:

"Modern biologists have abandoned the separate substance idea, but many still cling to a materialist version of the same mistake, based on the idea that somewhere in the brain the self is to be found as some neuronal process. The reason why that level of integration is too low is that the brain, and the rest of our bodies which are essential for attributes such as consciousness to make sense, are tools (back to the database idea again) in an integrative process that occurs at a higher level involving social interactions. We cannot attribute the concept of self-ness to ourselves without also doing so to others."[76]

Principle 10: there are many more principles to be discovered as a genuine 'theory of biology' does not yet exist

This principle of Noble is effectively his argument that the above nine principles are in no way exhaustive. There is still much to learn if we truly wish to understand biological systems. Evolution is not explanatory in the way some zealots wish it was. Natural selection may explain some 'what's', 'how's', 'where's', and 'when's', but it will not explain any 'why's', as those questions cannot be divorced from meaning, and meaning is not physical. Further, even the 'what's', 'how's', 'where's', and 'when's' are not fully explained through a paradigm of natural selection that cannot see beyond its own borders and limitations. A paradigm which refuses to acknowledge higher functions and principles will never be able to comprehend them. Like a two-dimensional line on a page, one can continue that line forever—let's pretend we have paper that lasts forever also!—but never reach another dimension. The moment an individual abandons their ideological dogmatism, they are able to lift the pencil off the page and appreciate a three- (or more) dimensional world for what it truly is.

Noble concludes his 2007 article on these principles with the following statement:

"In conclusion, I return to the theme with which this article began. Claude Bernard's concept of the constancy of the internal environment was the first example of multilevel functionality. It was critical in defining physiology as a subject distinct from the applications of physics and chemistry. The challenge we face today resembles that faced by Bernard in the mid-nineteenth century, but the chemistry involved is that of the molecule DNA. The answer though should be much the same. Higher-level control cannot be reduced to lower-level databases like the genome. A major part of the future of physiology surely lies in returning to our roots. Higher-level systems biology is, I suggest, classical physiology by another name."[76]

CHAPTER 11

The Progress of Evolutionary Thought

Hopefully the preceding chapters have proven useful in explaining an important bio-philosophical debate that took place almost under the radar recently. To the unsuspecting, the propriety and charm on display may have suggested that this was nothing more than a conversation between friends. However, the subtext, consequences, and clashes were evident to all those well-informed in the field.

I [Salman Butt] write this as someone who witnessed the same tension that was on stage during my own academic journey. Beginning with biochemistry—and having been proselytised like the rest of my cohort into the central dogma of Neo-Darwinism—I was once a believer of the school of thought I now write against. I remember seeing a rather unfortunate glow-in-the-dark mouse that somebody had engineered by inserting a gene from a fluorescent fish into its DNA. The logical progression from there to a stepwise chain of command was clear—and I do not blame myself for believing what I did. There was nothing I saw, and nothing I was taught, that disproved the idea of unilateral causation from genotype to phenotype. Things made sense, and when that happens to be the case, we often stop searching for more answers. However, as my postgraduate were about to tell me: stopping the search was a major mistake.

In typical bogan fashion, I chose for my PhD topic that beautiful enzyme: ribulose-1,5-bisphosphase; 'rubisco', as the cool kids call it. Every single carbon atom in our bodies, food, and clothing has, at one point, been through rubisco. Rubisco is what allows carbon to enter the biosphere and rubisco is what kicks off the Kreb's cycle. It is the most abundant enzyme on the planet and yet, for some reason, it is incredible inefficient, so plants need to produce bucketloads of it to sustain themselves.

The promise to every good reductionist biologist was that, if you could increase the efficiency of rubisco—even by a tiny amount—you would be able to make plants grow faster. If you could make plants grow faster, you could: reverse deforestation, remove gazillions of tonnes of carbon dioxide from the atmosphere, reverse global warming, and produce more food to sustain an exploding human population. The man who makes rubisco more efficient is the man who will save the world. It is not difficult, then, to understand why I chose to study this enyme in particular.

It is also no wonder why rubisco is among the most heavily studied enzymes of all time. We have studied rubisco like we studied little else, and much like those who studied for the human genome project, we realised that reductionist biology was not as helpful as it was meant to be. In one published paper—a paper I was very excited about at the time—we demonstrated that inhibiting an enzyme involved in cellulose production did not cause carbon to accumulate elsewhere in the biological pathways like we thought it would. Instead, it led to the down-regulation of rubisco activity at the start of the 'chain'.[84] That was not supposed to happen. If information was one-way, like the Neo-Darwinists had long argued, then our one way 'instruction' should not have been rejected. This felt more like communication between two decision-makers than the issuing of commands from below. In a real-world analogy, it was as if a Lego factory had stopped producing bricks as soon as children in another country to where the factory is based had stopped playing with them.

Such apparent purposiveness within cells, tissues, and organisms is an example of the emergent properties that a systems biologist studies. Reductionists like to deny the existence of these. Reductionist views historically had gained prominence over other paradigms not due to any deep thought but due to historical circumstances and the fact that simple conclusions are often reached before more complex ones in any field of study. A 20th century biologist can be forgiven for thinking of biology in simple, reductionist terms, just as Descartes can be forgiven for thinking of physics in simple, reductionist terms. What is unforgivable however, is self-blinding stubbornness upon such viewpoints despite the avalanche of evidence against them.

To think in terms of systems biology is not to reject any particular finding in biology. On the contrary, the more microscopically we search, the more we appreciate the bigger picture. What systems biologists like Noble argue is that these cogs are not privileged in any way over other cogs within the system, nor are they privileged over wider systems with emergent properties. Anthony Trewavas wrote:

> "Although reductionism and holism are often posed in opposition to each other, they can be reconciled. There is a need to understand how organisms are put together (reductionism) just as in turn there is a need to understand why they are put together in the way that they are (systems; holism). Both lines of approach are productive and answer different questions. The study of biological systems does, however, require an understanding of control and design structures, elements of structural stability, resilience, and robustness, which are not easily constructed from mechanistic information."[85]

When I was trying to purify rubisco those many years ago, something quite profound struck me. Rubisco did not flow freely in a cell like a small cogs waiting to meet a bigger cog which it would then instruct. Rubisco, like so many other enzymes in the body, especially those involved in reaction pathways, exists as part of a multi-enzyme complex. The implications of this need to be stated. Cells are not bags of water with chemicals slushing around inside them randomly until reactions occur and higher-level functions arise. Instead, they are amazingly well-organised and regulated cities that exercise both downwards and upwards causation, with bilateral communication and commands.

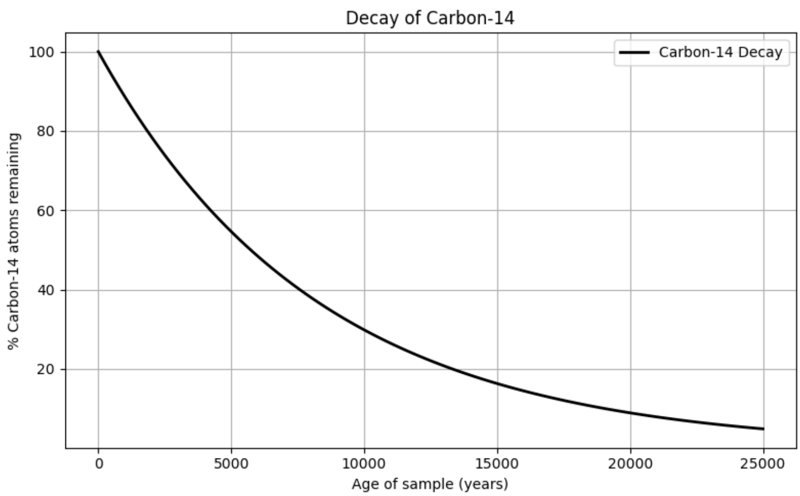
This brings us back to the definition of purpose, agency, and life. To Noble, to live is to harness stochasticity. In one paper, Raymond Noble and Denis Noble wrote:

> "A purely stochastic system might be defined as one in which all states are equally possible. Thus, all the possible combinations of two unbiased dice would occur by chance equally frequently. However, variations in biological systems are constrained and utilised to generate particular outcomes that are not as equally probable as all other possible outcomes. It is this that gives the system the potential to be creative. The system uses chance, but the outcome is not pure chance. It is goal directed. This is what we mean by agency."[86]

Chemical reactions that would take thousands of years if left to chance can happen in mere seconds through the right catalysts. Plants channel billions of photons of light from the sun into storehouses of energy. Immune cells turn on and off random mutations in specific areas of DNA to rapidly generate new antibodies. The more we discover, the less we see cells as bubbles of random reactants, and the more we see them as bustling cities

with organised transport systems, treasuries, zonal housing, recyling, and even immigration networks.

This is also true for biology in general. Like Descartes before them, 20th century biologists tried to explain the world in terms of physics and chemistry only. James Watson once wrote, “There are only molecules—everything else is sociology.”[87] But biology does not play ball. Physicists and chemists coming to the world of biology are often left perplexed by observations in the field. Look at what a standard stochastic graph look likes in physics of chemistry—they appear clean, symmetrical, predictable, and pattern-based. Take a look at the graph of carbon-14 decay below and ask yourself if that’s how a sentient organism behaves. It may be how a molecule behaves, but not a human. To see such linearity in organisms, one would need to study a tiny fraction of them or a tiny aspect of them. When studying an organism as a single, whole being, we do not find such behaviour.



Of course, there is a degree of oversimplification here, as you can find some exceptions, especially when humans are taking measurements in physics or chemistry, or in biology when you heavily curate data and produce neat trend lines to make them look nice for readers! But, if anything, these exceptions prove the rule. There is a palpable difference between biology on the one hand and physics and chemistry on the other.

Ground-breaking studies of individuality in animals and plants over the past century have accelerated the drive towards a systems-based understanding of biology. These studies have shown us that cells and organisms are not just machines. Machines can only function with precise specifi-

cations, but animals and plants display tremendous variability in their molecular, physiological, and even anatomical makeup, despite showing little differences phenotypically. Trewavas writes, "Measurements of mineral and vitamin content of the same species can vary 10- to 20-fold, ethylene content may vary 100-fold between individual apple fruits at the same stage of ripening, and individual poppy seed production can vary up to one millionfold."[85] Such huge molecular variation does not lead to a similar level of change in phenotypes because organisms are not machines—they are robust and responsive systems.

Recent disruptions in supply chains following the Brexit fiasco have shown us just how sensitive to change and commands unthinking systems can be. When something is operating with machine-like efficiency, the price is almost invariably a lack of robustness, redundancy, and compensatory mechanisms built in. Thus, when one cog is moved out of place, the wider ecosystem feels it acutely. Biological systems are more robust, and the compensatory mechanisms they have developed are characteristic of wide-reaching systems, not inorganic molecules. Thus, if I had somehow managed to make rubisco work faster, before depositing that rubisco back into a plant, it would not necessarily have made the plant grow faster.

For some people, such discoveries are nuisances that need to be patched over if the dogma of the day is to be defended, but this is not how science should work. One should be excited by the prospect of new theories emerging. I was tutored by scientists who knew what science was, as well as what science should never become. Thus, I embraced the epiphany that reached me about systems biology. The same cannot be said for Dawkins and those like him. Science in the real world is a human enterprise full of human errors, cultures, histories, and emotions. Noble once said, "Science does not happen like a blank slate without assumptions. That type of science is just stamp collecting. I don't do that."[73] We get the most out of science when we treat it less like revelation giving absolute truths and more like what my undergraduate tutor used to describe it as: telling the best story we can at the moment. The story should always be open to change, and that includes a complete rewrite.

Scientists often rely on the use of metaphors and imagery. Responsible scientists and science writers know—and make clear—when they are using metaphors to explain a concept. They may describe cells as small bubbles, DNA as microscopic codes, atoms as tiny balls of energy, and electrons as tiny dots of energy whizzing around on discrete orbits. Most of us know this is not literally the case, and we should all have the intellectual humility to clearly say that these are simplifications and models based on whatever

understanding we can muster at any given time with our limited information and intellects.

One reason people struggle to see past their own dogmas is that they have made these dogmas paradigms, lenses through which they view all incoming information. These mercurial models—what some people call 'now explanations'—are taken as eternal, unchangeable truths, and any information that arises is then to be reinterpreted and forced to fit in with these truths as best it can. If it cannot fit, it is unfairly dismissed. This is what I meant by those who take scientific dogmas as revelation—there is no epistemic justification for such an action.

The great irony is that these Neo-Darwinists who fight so strongly for their beliefs are often as they are because they are reacting to excesses of the religionists of yesteryear, yet they have fallen into the exact same trap as those men of old. Noble has described the modern synthesis as having all the hallmarks of religion, claiming that it not only has its fanaticism and zealotry, but that it now has a concept of original sin—"We are born selfish!"[73] Perhaps more worryingly, we find that this new religion is inquisitorial to all heretics who oppose it. People are often unaware of this aspect of the scientific community. They'd be shocked to hear that Noble and his colleagues went through much censorship. Noble was unable to publish his views until after retiring from leading an active lab in 2005 out of fear for the careers of his team members. He is a fellow of the Royal Society, but his talks and meetings have been met with harshness and fury. One interviewer who was speaking to Noble commented that the "bias that we associate with religious belief applies just as much to religious disbelief if you're not open-minded about evidence."[6]

At a civilisational level, those reacting to an old understanding of religion went full circle and began a new religion of Scientism. The natural sciences were upgraded from carefully sceptical edifices concerned with increasingly accurate 'now explanations' to an intolerant naturalism that wishes to explain everything through itself, not realising that doing so means it definitionally cannot transcend itself. Naturalism moved beyond a pragmatic approach to investigation and into an ideology of absolute philosophical truth—methodological naturalism became philosophical naturalism.

And what for? All this philosophical two-stepping does not achieve what the Neo-Darwinists seem to think it does. They are just as wrong about the Third Way of Evolution opening up a space for God as they are about Neo-Darwinism closing this space. Neither a reductionist nor a holist paradigm is anti-theological or anti-philosophical. To think otherwise is to make an egregious category error and to display a coping mechanism.

Decribing biological processes in terms of bottom-up causation or multilateral communicative enterprises does not mean one affirms or rejects God. Oddly, the magic-like properties Neo-Darwinists endow DNA with are, if anything, more mystical than those properties given to biological systems by Noble. At least the Third Way of Evolution does away with DNA's agency and the rather conspicuous problem of slow, gradual, random mutations at the behest of purely physical laws—without a fine-tuner to guide the process—requiring many billions more years to play out than the world seems to have existed for. And at least it shows how genetic mutations and evolution can be directed and accelerated by the cells of an organism in response to internal and external pressures.

There is another feature of religion that is, perhaps, what the more zealous Neo-Darwinists crave most but can't admit: a feeling of certainty. There is something incredibly attractive about a simple model that explains everything. At the same time, there is absolutely no obligation for the world to be intelligible to us through such simple models. This contrast means we often oversimplify complex matters in an unhelpful way. Noble writes:

> "An important motivation towards reductionism is that of reducing complexity. The idea is that if a phenomenon is too complex to understand at level X then go down to level Y and see, first, whether the interactions at level Y are easier to understand and theorize about, then, second, see whether from that understanding one can automatically understand level X."[88]

Whilst simple models are appealing, they are not always correct. It requires humility, openness, and integrity to stop oneself from attaching certainty to any scientific model, including a simple one that they really, really want to work. This is the human side of science that is often forgotten, and without safety nets in place to protect ourselves from the human pitfalls of arrogance, deceitfulness, and idiocy, we risk hampering the efforts of real science. Just imagine the number of young scientists who were held back from studying biological systems due to the zealotry of the Neo-Darwinist clergy. This is not what science should be about.

And whilst there is a long way to go yet, Noble's resilience and biological acumen, as well as those of his peers who believe similarly, are reaping fruits. Progress is being made, in many unexpected ways. In another ironic twist, it seems that the soul of science is being saved through selective pressure producing hardened diamonds such as Noble that can then pass their knowledge onto future generations. Evolution is evolving in a revolutionary way, quite the thought to end this book on.

Concluding Remarks

Neo-Darwinism is dead. Hopefully, this book has shown some of the ways in which this death took place. A gene-centric, reductionist worldview is untenable in the face of multifaceted, complex, and interdependent systems. Causality cannot be limited to a single level—especially when that level is itself composed of parts—in a multicausal and multipotent organism. The self cannot be assumed to be illusory or a product of a single physical entity without evidence for this. Correlation between genes and effects does not prove a causal link. Metaphors are helpful until they are taken literally or used to blur the lines between fact and fiction.

The catalogue of errors in the Neo-Darwinist paradigm is lengthy. However, one should not be egregious in tearing up this catalogue. Instead, we must offer something better, sounder, and truer to reality in return. This book looked through the alternative paradigm offered by the eminent biologist Denis Noble, but he is not alone in his views. These views are powerful and look at organisms as systems within systems that are more than the sum of their parts.

Then why is it that Noble's arguments have not gained the mainstream traction they should have given their polemic worth? The answers to this are many. For one, there is the often ignored elephant in every room that Dawkins and his followers enter. These individuals are committed to maximally reductionist views as they feel these positions are incompatible with spiritual worldviews. If they can reject the self, the soul, the mind, free will, and even emotions, then they can paint a picture of a world in which there is no good or evil and no judgement or accountability. In this sterile, inorganic world, there is no meaning or value and there is no reason to believe in God. This is the context behind the extreme positions Dawkins and many modern biologists put forward, and it is a fact they are often very uncomfortable admitting to.

However, it would be unfair to say this is the only reason. Dawkins' polemical writing style is powerful and captivating, meaning readers often

don't realise when they are slipping into metaphorical discourse and when they are slipping back to literal claims. Dawkins makes grand claims and then qualifies these aggressively in other parts of his work, leading to those who have not read him well to be confused regarding what he is actually arguing. Dawkins' writing in this style is rather peculiar in the biological world, and its novelty helped propagate his work.

Exacerbating the issue is the lack of evidenced alternative paradigms in which to frame matters. The truth is, there is a lot we do not know. Admitting that is difficult for many people, and so when someone offers an ideologically potent worldview that is enforced with great zeal and confidence, it is quickly taken up by those who were yearning for something like it.

Ultimately, we need to have some humility and appreciate that matters are often more complex than is comfortable for us. There are many things that we do not know and even things that we cannot know. The answer is not to reduce all matters to building blocks in a manner resembling the atomists of old. Instead, we need to appreciate the building blocks, the buildings they form, and the nations these buildings go on to be a part of. We need to appreciate the systems at work. The world of certainty and selfish genes is dead. The world of curious and spiritual people is alive.

Indeed, in the creation of the heavens and the earth; the alternation of the day and the night; the ships that sail the sea for the benefit of humanity; the rain sent down by Allah from the skies, reviving the earth after its death; the scattering of all kinds of creatures throughout; the shifting of the winds; and the clouds drifting between the heavens and the earth—*in all of this* are surely signs for people of understanding.

Quran 2:164

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